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Ice Cream Manufacturing Plants in the Midwest

Methods, Equipment, and Layout

Marketing Research Report No. 477

UNITED STATES DEPARTMENT OF AGRICULTURE
Agricultural Marketing Service
Transportation and Facilities Research Division
in cooperation with
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PREFACE

This research was conducted cooperatively by the Purdue University Agricultural Experiment Station and the U.S. Department of Agriculture. The data on work methods and equipment were obtained from studies of ice cream manufacturing operations throughout Indiana. The purpose of the research was to provide ice cream plant operators with data and guidelines which could be used in establishing and operating ice cream plants more efficiently. The study is part of a broad program of research aimed at improving market efficiency and expanding markets for farm products.

The work was conducted under the general supervision of George E. Turner, marketing research analyst, Agricultural Marketing Service, and Charles E. French, professor of agricultural economics, Purdue University.

Many dairy plant operators made their plants available for detailed studies of ice cream manufacturing operations. Dairy equipment companies provided current price data for ice cream plant equipment.

Dean R. Frazeur, associate professor of dairy manufacturing, Purdue University, and Verne D. Rhodes, assistant professor of dairy manufacturing, Purdue University, provided assistance and many valuable suggestions.

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Washington, D. C. October 1961

SUMMARY

Improved work methods and plant layout can reduce costs in a typical plant manufacturing 150,000 gallons of ice cream annually by $23.69 per 1,000 gallons, or approximately $3,600 annually. This reduction is based on a plant manufacturing five flavors of ice cream and packaging it in seven sizes of containers.

All the reductions in costs with the improved methods are in equipment; labor costs are higher with these methods. The reduction in equipment cost offsets the increased labor cost, primarily because of the small volume on which this analysis is based. Equipment costs are reduced and labor costs are increased by using relatively low-cost equipment and manual methods, rather than high-cost labor-saving equipment, to perform certain operations.

The largest reduction in costs is in the packaging cycle. Costs per 1,000 gallons are reduced $12.34 by filling containers manually. Other significant savings, $5.54 for receiving ingredients for ice cream mix and $3.69 for preparing the mix, are the result of reduced equipment costs. Costs are increased with improved methods and plant layout in loading out and in cleaning the equipment. Using relatively high-cost equipment increases the cost of loading out, and more labor is required to clean the equipment used with improved methods.

A layout based on the improved methods is suggested for a plant manufacturing 150,000 gallons annually. The major components of the plant are a can storage cooler, a mix area, a freezing and packaging area, a hardening room, a dry storage room, a laboratory, a machinery room, and a main office. The layout shows the relationship between the major components and a suggested equipment arrangement for each work area. A layout showing how the proposed plant could be expanded to manufacture 300,000 gallons of ice cream annually is included in the report.

Ice Cream Manufacturing Plants in the Midwest
Methods, Equipment, and Layout

By James C. Taylor, industrial engineer[1]
Transportation and Facilities Research Division
Agricultural Marketing Service

INTRODUCTION

The production and sale of ice cream throughout the United States rose from about 554 million gallons in 1950 to 701 million in 1959, an increase of 27 percent. During the latter part of the decade, approximately 3,400 plants were manufacturing ice cream. These plants, both specialized ice cream plants and diversified dairy plants, operated with buildings and equipment ranging in age from less than 1 year up to 30 years. In some of the older plants, work methods have changed in only minor respects since inception of the business. In others, an effort has been made to employ the latest methods and equipment.

As the volume of manufactured ice cream has increased, a number of developments have had a material effect on manufacturing methods. Packaging equipment has been developed to increase the capacity, and, in many cases, to reduce the cost of packaging operations. Improved processing equipment of various types and sizes has been made available to the plant operator, and a number of labor-reducing devices have been developed.

One significant result of these developments is that the manufacturer must select the most economical method of performing each operation from the wide variety of work methods and equipment currently available. Items of equipment which result in profitable operation at one plant may cause losses at another. The plant operator must, therefore, evaluate the effect of each method and each item of equipment on his particular plant if he is to maintain a competitive position.

This study was undertaken to provide assistance to the ice cream manufacturer in the scientific evaluation of work methods and equipment. The objectives were to (1) measure the relative efficiencies of various work methods and various types and combinations of types of equipment used in ice cream plants; (2) compare the various combinations of work methods and equipment to determine their effects on the economy of plant operations; and (3) develop plant layouts showing arrangement of equipment and flow of materials.

Research methods

Research was conducted in ice cream manufacturing plants of many types and sizes throughout Indiana. The research covered the major types of processing, packaging, and materials-handling equipment currently in use, and the major variables that significantly affect the use of the equipment. These variables include number of workers in a crew, design of the plant, volume handled by the plant, and arrangement and utilization of equipment.

Time studies were made of the various work methods to (1) determine the time required for performing each operation; (2) determine the total man-hours of labor and machine-hours of equipment required; and (3) provide a basis for developing improved work methods and plant designs. From these data, labor and equipment costs for performing all operations by the use of specified methods and equipment were computed. A comparison of these costs shows the relative efficiencies obtained with various methods and types of equipment in ice cream manufacturing plants.

Management costs, facility costs, and costs of ingredients and supplies have not been included in this study. These data, therefore, do not reflect total plant costs.

Labor costs

On the basis of data gathered from Indiana plants, a wage rate of $1.75 per hour was used. This rate includes wages, Federal Insurance Compensation Act taxes, unemployment insurance, workmen's compensation payments, and certain benefits such as vacations and group insurance. Labor costs for a particular operation are determined by multiplying the total man-hours of productive and unproductive labor by the hourly wage rate.

Equipment costs

Equipment prices were obtained from dairy equipment manufacturers and are based on average f.o.b. factory prices for 1958 and 1959. Equipment costs are grouped into two categories, ownership costs and operating costs.

Ownership costs include depreciation, based on the straight-line method and using life expectancy tables from Internal Revenue Service Bulletin

[1] Resigned.

"F"; interest, based on a 6-percent rate of the average investment; and typical taxes and insurance rates in Indiana, a combined figure of 2.7 percent on the initial investment. These costs are considered to be fixed and are computed on an annual basis.

Operating costs are based on representative costs in Indiana. They include electricity at 2.7 cents per kilowatt-hour, fuel at 6.7 cents per therm, water at 0.018 cent per gallon, and maintenance at 35 percent of the initial cost over the life of the equipment.

Combining total ownership and operating costs and dividing by the annual usage provides an hourly cost for equipment utilization.

Definition of terms

Base time is the time required by a skilled worker to perform an operation at a normal pace.

Productive time is the time allowed for performing an operation. It is computed by adjusting base time for personal and fatigue allowance.

Unproductive time is time which is spent on the job but which cannot be considered creative. It includes such items as unavoidable delay and idleness.

Machine-regulated wait time is the time a worker or workers are idle because the machine does not provide sufficient productive work to keep them occupied.

Personal allowance is the time allowed a worker for his personal needs, such as going to the lavatory, washing up, and drinking water. In this report a personal allowance of 5 percent was added to all base times with the exception of those involving work in the ice cream hardening room. Because of the extremely low temperatures in the hardening room, a personal allowance of 10 percent was added to the base time for any work performed in the room.

Fatigue allowance is the time allowed a worker to compensate for weariness induced by the work. The inherent fatigue is determined by the nature of the work, and the allowance added to the base time varies from 5 to 25 percent.

Elapsed time is the total time consumed by an operation from beginning to end; it includes productive time plus any necessary unproductive time.

ICE CREAM PLANT OPERATIONS

On the basis of sales forecasts and available storage space, plant management determines the volume of ice cream that should be carried as inventory in the cold storage room during each season of the year. Daily production requirements are based on the quantities of each flavor and each container size that are needed to replenish the stock. Consequently, although the volume of ice cream manufactured daily might be essentially constant, the daily volume produced in different flavors and container sizes is quite irregular. The number of flavors and container sizes produced by individual plants varies widely, and the variation has a material effect on the labor and equipment requirements for performing all manufacturing operations.

This study deals with the labor and equipment requirements and costs for an ice cream plant with an annual volume of 150,000 gallons, about the size of the average ice cream plant in Indiana in 1956. It is assumed that the plant manufactures five flavors of ice cream and employs seven different sizes of package. The number of flavors, the container sizes, and the distribution of production by size of container are based on studies of a selected number of plants in Indiana. The assumed distribution of production by flavor and container size is shown in table 1.

It is assumed that the plant operates 8 hours per day, 5 days per week, and that the same quantity of ice cream is manufactured each day. The ice cream will have an overrun (volume of ice cream in excess of the volume of mix) of 100 percent. Thus the manufacture of 150,000 gallons of ice cream will require 75,000 gallons of ice cream mix. It is assumed that there is no in-plant loss.

Ice cream plant operations are divided into seven major operating cycles for the purpose of analyzing labor and equipment requirements: (1) Receiving mix ingredients, (2) preparing mix, (3) freezing ice cream, (4) packaging ice cream, (5) storing it, (6) loading it out, and (7) cleaning manufacturing equipment. The operations comprising each cycle are analyzed on the basis of equipment and work methods used. The total labor and equipment requirements for each operation are computed on the basis of 1,000 gallons of ice cream. Tables 15 to 27, inclusive, in the appendix, show the labor requirements for performing each element of the various operations, by each work method. The requirements are affected materially by the distances products and materials are moved between work stations and departments of the plant. The average distances are based on the suggested layout (fig. 27).

Time values established for specific operations should not be considered as standards, but as devices for measuring the relative efficiencies of various methods.

Operating methods are divided into two groups for comparison. Combination "A" methods are those commonly used in ice cream plants studied. Combination "B" methods are the lowest cost methods as determined by an improved layout and

TABLE 1.—*Flavors of ice cream produced and size of containers: Percentages of total production assumed for a plant manufacturing 150,000 gallons annually*

Flavor	Container size							Percentage of total
	5-gallon	2½-gallon	Gallon	Half-gallon	Pint	5-ounce	3-ounce	Total	
	Gallons	*Gallons*	*Gallons*	*Gallons*	*Gallons*	*Gallons*	*Gallons*	*Gallons*	*Percent*
Vanilla	4,420	7,800	37,440	28,704	7,592	3,016	1,540	90,512	60.34
Chocolate		2,080		5,616	5,200			12,896	8.60
Fruit		3,900		10,608	2,080			16,588	11.06
Nut		1,560		4,888	1,040			7,488	4.99
Multiflavor		4,680		10,556	7,280			22,516	15.01
Total	4,420	20,020	37,440	60,372	23,192	3,016	1,540	150,000	100.00
Percentage of total	2.95	13.35	24.96	40.24	15.46	2.01	1.03	100.00	

the most economical work methods. In several operations, combination B methods are manual methods. The lowest cost methods are based on a plant manufacturing 150,000 gallons annually, and larger plants might profitably use relatively high-cost equipment instead of the manual methods.

Receiving ingredients for ice cream mix

Many plants manufacturing ice cream, particularly those with low production, purchase mix from other ice cream manufacturers or from firms which specialize in making mix. The most common reason for a plant to purchase mix is that management considers it more economical to buy mix than to invest in mix-making equipment. Naturally a plant that purchases mix does not receive mix ingredients.

For the purpose of analyzing the labor and equipment requirements for a plant manufacturing 150,000 gallons of ice cream annually, it is assumed in this report that the plant prepares its mix and therefore receives mix ingredients. The ingredients consist of 40-percent cream, condensed skim milk, cane sugar, corn sugar, emulsifier, stabilizer, and water. The composition of plain ice cream mix, by weight of ingredients required to prepare a 500-gallon batch, is shown in table 2. A 500-gallon batch of mix is required in making 1,000 gallons of ice cream.

It is also assumed that cream and skim milk are received either in bulk (tank trucks) or 10-gallon cans, cane and corn sugar in 100-pound bags, and emulsifiers and stabilizers in 55-gallon drums. Since, however, emulsifiers and stabilizers are used in small quantities, their receipts are not considered.[5] Nor is water considered. This analysis deals with unloading, transporting, and storing cream, skim milk, cane sugar, and corn sugar.

The labor and equipment requirements for receiving ingredients are computed on a basis of 1,000 gallons of ice cream. The quantities of fluids required per 1,000 gallons of ice cream are 319.81 gallons (146.27 gallons of cream and 173.54 gallons of skim milk). The quantities of cane and corn sugar are 763 pounds. Two methods are used to perform the receiving operation—bulk and handtruck and can and handtruck. One worker is required for each method.

TABLE 2.—*Plain ice cream mix: Ingredients used in preparing a 500-gallon batch* [1]

Ingredient	Weight	Proportion of total weight
	Pounds	*Percent*
40-percent cream	1,214.00	26.25
Condensed skim milk	1,631.30	35.27
Cane sugar	601.25	13.00
Corn sugar	161.90	3.50
Emulsifier	9.25	.20
Stabilizer	9.25	.20
Water	998.10	21.58
Total	4,625.05	100.00

[1] These ingredients result in ice cream mix with a butterfat content of 10.53 percent, a nonfat milk solids content of 10.93 percent, and a total solids content of 27.82 percent.

Bulk and handtruck method

With the bulk and handtruck method fluid ingredients are received in tank trucks and are pumped directly from the tank into cream and skim milk holding tanks. Cane and corn sugar are received in 100-pound bags and transported to storage.

In receiving fluid ingredients the worker closes the drain valves on the storage tanks, starts the pump, waits for the milk and cream to be pumped from the tank truck into the storage vat, then stops the pump. The truck driver connects and discon-

nects the truck tank drain hose. His labor is not included in the plant's labor requirements. The elapsed time required for receiving cream and skim milk for 1,000 gallons of ice cream is 0.47 hours.

The worker loads bags of cane and corn sugar onto a 4-wheel handtruck at the door of the plant and transports them an average distance of 16 feet to point of storage. He manually removes the bags from the truck, stacks them on a pallet, then returns the truck to the entrance door. The elapsed time per 1,000 gallons of ice cream for receiving cane and corn sugar is 0.06 hour.

The labor and equipment requirements and costs per 1,000 gallons of ice cream for receiving ingredients are as follows:

	Man-hours	*Cost*
Labor	0.53	$0.93
	Machine hours	
Equipment:		
600 gallon cream tank	58.40	2.20
600 gallon skim milk tank	58.40	2.20
6,000 pound-per-hour centrifugal pump	.47	.17
2 inch I.D. piping	.47	.48
4 wheel handtruck	.06	.04
Total	117.80	5.09
Total cost for labor and equipment		6.02

The requirements for two 600-gallon storage tanks are based on the use of the tanks 24 hours a day, 7 days a week, since a supply of ingredients is maintained in them at all times.

Can and handtruck method

When this method is employed, cream and skim milk are received in 10-gallon cans, and sugar is received in 100-pound sacks. The canned ingredients are stored at a temperature of 30° to 35° F. in either a can storage cooler or a vestibule of the hardening room. The ingredients remain in cans until they are needed for the mixmaking operation. To receive cans, a worker loads them onto a 4-wheel handtruck, moves the truck 11 feet to the storage area, unloads and stacks cans, and returns empty truck to the receiving point. The same handtruck is used for receiving both liquid and dry ingredients. The elapsed time required for receiving cans of fluid ingredients by this method is 0.19 hour per 1,000 gallons of ice cream.

Sugar is received in the same manner as in the bulk and handtruck method.

The labor requirements per 1,000 gallons of ice cream for receiving fluid and dry ingredients with the can and handtruck method are 0.25 man-hour. The cost is $0.44. The equipment cost based on the use of a 4-wheel handtruck for 0.25 machine-hour is $0.04. The total cost is $0.48.

Comparison of methods

The cost for receiving ingredients with the can and handtruck method is $5.54 per 1,000 gallons of ice cream less than with the bulk and handtruck method. Most of the reduction in cost with the can and handtruck method is the result of lower equipment costs. Storage tanks are not used with this method because fluid ingredients are stored in the containers in which they are received. Although practically no physical labor is involved in receiving fluid ingredients in bulk, the worker's waiting time during pumping is more than double the time required for handling cans.

Preparing ice cream mix

One of the most important processes involved in the manufacture of ice cream is preparing the mix. The method of preparing mix affects not only the flavor and texture of the finished product, but the cost as well. Among the plants which manufacture their own mix, no two processes are exactly alike. Ingredients, equipment, mix storage periods, and pasteurizing time and temperature all vary from plant to plant.

The mix ingredients used in this analysis are listed in table 2. It is assumed that mix is stored overnight. The pasteurizing time and temperature used in this analysis are based on the regulations specified by the Indiana State Board of Health. Its regulations state that the mix shall be held at a temperature of 155° F. for 30 minutes, or at a temperature of 175° F. for 25 seconds.

Preparing the mix involves assembling and transporting ingredients from the storage areas to the mixing area, weighing and mixing ingredients, and pasteurizing, homogenizing, cooling, and storing the mix. Four methods may be used for processing and storing mix: (1) Bulk and H.T.S.T. (high temperature short time), (2) can and H.T.S.T., (3) bulk and batch, or (4) can and batch.

Bulk and H.T.S.T. method

When the bulk and H.T.S.T. method is employed, raw cream and skim milk are pumped directly from the storage tanks to a weigh tank (fig. 1). They are then pumped to a mix tank, mixed with other ingredients, and finally pumped through the H.T.S.T. pasteurizer, through the homogenizer, and to the storage vats. The worker starts the pump to pump cream from the storage tank to a 50-gallon weigh tank, weighs the cream and pumps it to the mix tank, and stops the pump. He weighs and pumps skim milk to the mix tank in the same manner. He then pushes a 4-wheel handtruck to the storage area for dry ingredients, loads sacks of cane and corn sugar onto the truck, and pushes it an average distance of 32 feet to the mixing area. There a second worker helps him open the sacks and empty them into the mixing tank. The second worker performs other ice cream making operations the remainder of the time. The first worker adds water to the weigh tank, weighs it, and pumps it to the mixing tank. The final ingredients, the stabilizer and the emulsifier, are taken from drums in the dry storage area, measured into buckets of water, mixed, and poured into the mix-

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FIGURE 1.—Liquid mix ingredients are measured in a weigh tank supported on a scale before the mixing operation.

ing tank. Mechanical agitators in the tank continuously mix ingredients as they are added to the tank.

From the mixing tank the mix is pumped to and through the pasteurizer (figs. 2 and 3) where it is pasteurized and cooled to 40° F., through the homogenizer (fig. 4), and into a storage vat (fig. 5), where it is further cooled to 30° F.

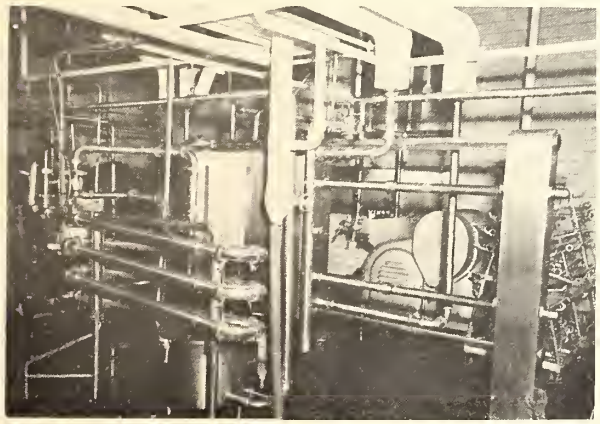

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FIGURE 2.—An H.T.S.T. pasteurizer with a holding tube in the left foreground and a pasteurizer surge tank immediately behind the tube.

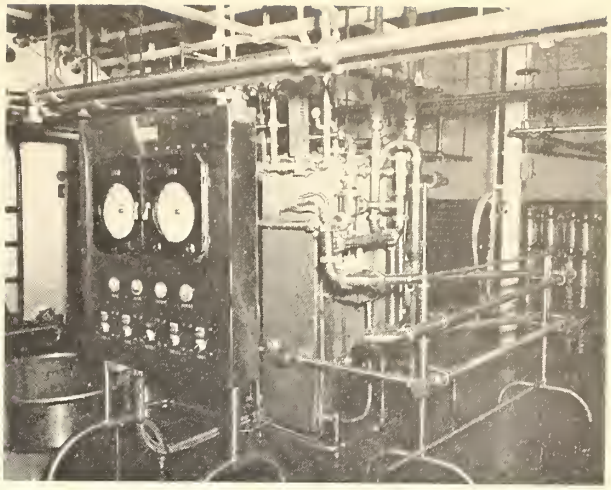

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FIGURE 3.—The H.T.S.T. panel houses control switches and indicates and records conditions within the pasteurizer.

The elapsed time per 1,000 gallons of ice cream for processing and storing mix by the bulk and H.T.S.T. method is 2.24 hours. The labor requirements, based on one worker for 2.24 man-hours and one for 0.05 man-hour, are 2.29 man-hours. The labor and equipment requirements and costs per 1,000 gallons with the bulk and H.T.S.T. method are as follows:

	Man-hours	*Cost*
Labor	2.29	$4.01
	Machine hours	
Equipment:		
4-wheel handtruck	0.14	.10
6,000-pound-per-hour centrifugal pump	.47	.17
1½-inch I.D. piping	.47	.58
50-gallon weigh tank	1.20	.46
Platform scale	1.20	.90
6,000-pound-per-hour centrifugal pump	.64	.18
1½-inch I.D. piping	.64	.13
300-gallon mix tank	1.60	1.59
6,000-pound-per-hour centrifugal pump	.86	.18
10,000-pound-per-hour centrifugal pump	.86	.11
5 400-pound-per-hour H.T.S.T. pasteurizer	.86	14.75
600-gallon-per-hour homogenizer	.86	4.21
1½-inch I.D. piping	.86	0.61
300-gallon storage vat	58.40	2.31
600-gallon storage vat	58.40	3.50
Total	127.46	29.78
Total cost for labor and equipment		33.79

The variation in costs of identical items of equipment is due to the cost (ownership and operating) of the equipment and the number of hours it is used annually.

Can and H.T.S.T. method

The can and H.T.S.T. method is employed when raw skim milk and cream are received in 10-gallon

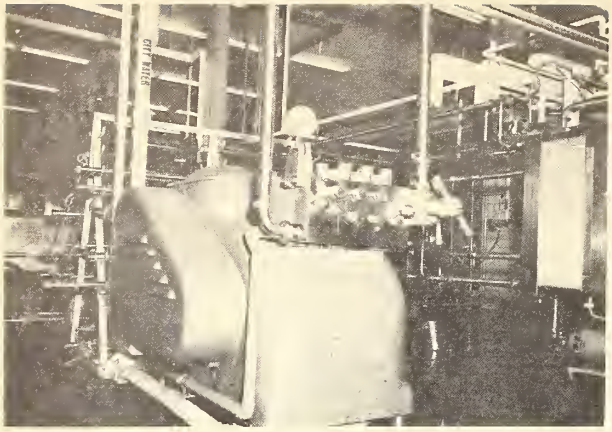

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FIGURE 4.—The homogenizer breaks up and intersperses particles of mix.

cans, and when mix is pasteurized by an H.T.S.T. pasteurizer. With this method, the worker loads 10-gallon cans of cream and skim milk on a 4-wheel handtruck and transports them approximately 15 feet from the storage cooler to the mixing area. The cans are then opened and emptied into the weigh tank, and the skim milk and cream are weighed and pumped to the mixing tank. Cans are rinsed and returned to the cooler. Water, cane and corn sugar, stabilizer, and emulsifier are added to the tank in the same manner as that described for the bulk and H.T.S.T. method. After all ingredients have been weighed and mixed, the method of pasteurizing, homogenizing, and storing is identical to the bulk and H.T.S.T. method.

The elapsed time per 1,000 gallons of ice cream with this method is 2.23 hours. The labor requirements, based on one worker for 2.23 man-hours and one worker for 0.05 man-hour, are 2.28 man-hours. The labor and equipment requirements and costs per 1,000 gallons with the can and H.T.S.T. method are as follows:

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FIGURE 5.—Ice cream mix is stored and cooled in holding vats.

	Man-hours	*Cost*
Labor	2.28	$3.99
	Machine-hours	
Equipment:		
4-wheel handtruck	0.61	0.10
50-gallon weigh tank	.86	.46
Platform scale	.86	.91
6,000-pound-per-hour centrifugal pump	.64	.18
1½-inch I.D. piping	.64	.13
300-gallon mix tank	1.60	1.59
6,000-pound-per-hour centrifugal pump	.86	.18
10,000-pound-per-hour centrifugal pump	.86	.11
5,400-pound-per-hour H.T.S.T. pasteurizer	.86	14.75
600-gallon-per-hour homogenizer	.86	4.21
1½-inch I.D. piping	.86	.61
300-gallon storage vat	58.40	2.31
600-gallon storage vat	58.40	3.50
Total	126.31	29.04
Total cost for labor and equipment		33.03

Bulk and batch method

The bulk and batch method of processing and storing mix is employed when liquid ingredients are received and stored in bulk, and individual batches of mix are pasteurized in a vat. Ingredients are assembled and weighed in the manner described for the bulk and H.T.S.T. method but are mixed in a pasteurizing vat. As ingredients are added to the vat, the worker turns on the steam at the pasteurizing vat, and the ingredients are heated to a temperature of 160° F. (mix is often heated to 160° to compensate for any temperature drop during the holding period). The steam is then turned off, and the mix is held in the vat for 30 minutes. After the holding period the mix is drained from the vat, pumped through a homogenizer, a plate cooler, which reduces the temperature to 40° F., and thence to a storage vat where the temperature is lowered to 30° F.

The elapsed time is 4.00 hours per 1,000 gallons of ice cream. The labor required, based on one worker for 4.00 man-hours and one worker for 0.05 man-hour, is 4.05 man-hours. The labor and equipment requirements and costs per 1,000 gallons of ice cream with the bulk and batch method are as follows:

	Man-hours	*Cost*
Labor	4.05	$7.09
	Machine-hours	
Equipment:		
4-wheel handtruck	0.14	.10
6,000-pound-per-hour centrifugal pump	.47	.17
1½-inch I.D. piping	.47	.58
50-gallon weigh tank	1.20	.46
Platform scale	1.20	.90
6,000-pound-per-hour centrifugal pump	.64	.18
1½-inch I.D. piping	.64	.16
300-gallon pasteurizing vat	3.31	5.13
600-gallon-per-hour homogenizer	.86	4.21
5,400-pound-per-hour plate cooler	.86	5.48

Equipment—Continued	*Machine-hours*	*Cost*
1½-inch I.D. piping	.86	.59
300-gallon storage vat	58.40	2.31
600-gallon storage vat	58.40	3.50
Total	127.45	23.77
Total cost for labor and equipment		30.86

Can and batch method

The can and batch method involves assembling and weighing ingredients in the manner described for the can and H.T.S.T. method, and pasteurizing, homogenizing, cooling, and storing mix in the manner described for the bulk and batch method.

The elapsed time per 1,000 gallons of ice cream is 3.99 hours. The labor required, based on one worker for 3.99 man-hours and one worker for 0.05 man-hour, is 4.04 man-hours. The labor and equipment requirements and costs per 1,000 gallons of ice cream for processing and storing mix with the can and batch method are as follows:

	Man-hours	*Cost*
Labor	4.04	$7.07
	Machine-hours	
Equipment:		
4-wheel handtruck	0.61	0.10
50-gallon weigh tank	.86	.46
Platform scale	.86	.91
6,000-pound-per-hour centrifugal pump	.64	.18
1½-inch I.D. piping	.64	.16
300-gallon pasteurizing vat	3.31	5.13
600-gallon-per-hour homogenizer	.86	4.21
5,400-pound-per-hour plate cooler	.86	5.48
1½-inch I.D. piping	.86	.59
300-gallon storage vat	58.40	2.31
600-gallon storage vat	58.40	3.50
Total	126.30	23.03
Total cost for labor and equipment		30.10

Comparison of methods

The lowest cost method for preparing mix is the can and batch method (table 3). The low cost of this method is due solely to the relatively low-cost equipment used with it. Labor costs are almost as great with this method as with the bulk and batch method and are considerably greater than with either the bulk and H.T.S.T. or the can and H.T.S.T. methods. It does not require the pump and piping required by the bulk and batch or bulk and H.T.S.T. methods for transferring cream and skim milk from storage. Furthermore, a vat pasteurizer costs considerably less than the H.T.S.T. pasteurizer.

Freezing ice cream

Freezing is the process which converts liquid ice cream mix to semifrozen ice cream. The process occurs as the mix is pumped through a freezing cylinder, which is enclosed by a full-flooded ammonia jacket. The cylinder houses a revolving mutator, or dasher, which incorporates air into the mix, scrapes frozen ice cream from the cylinder walls, and ejects the ice cream from the cylinder. Since the ice cream must be packaged, the function of the freezer is to produce a stiff semifrozen product rather than a frozen product.

Freezing is characterized by short production runs, necessitated by frequency changes in flavors and container sizes. Packaging and storing operations are paced by the freezing rate. Thus a delay in freezing automatically results in a delay in these other operations.

Two types of freezers are commonly found in ice cream plants—the single-tube freezer and the three-tube freezer. A plant with an annual volume of about 150,000 gallons would require either two single-tube freezers or one three-tube freezer. The labor and equipment requirements for freezing, therefore, are analyzed on the basis of freezing ice cream by the three-tube method and by the single-tube method.

The freezing rate of both types of freezers varies widely, and plants often operate the freezers at less than full capacity. Usually the rate at which freezers are operated is determined by the size and organization of the work crew. The rate is also

TABLE 3.—*Preparing ice cream mix: Labor and equipment requirements and costs per 1,000 gallons of ice cream in a plant manufacturing 150,000 gallons annually, by method* [1]

Method	Requirements		Costs		
	Labor	Equipment	Labor	Equipment	Total
	Man-hours	*Machine-hours*	*Dollars*	*Dollars*	*Dollars*
Bulk and H.T.S.T.	2.29	127.46	4.01	29.78	33.79
Can and H.T.S.T.	2.28	126.31	3.99	29.04	33.03
Bulk and batch	4.05	127.45	7.09	23.77	30.86
Can and batch	4.04	126.30	7.07	23.03	30.10

[1] For percentage of volume packaged in each size of container, see table 1.

based on the size of the container being filled. Freezers would be operated at a much faster rate for filling 5-gallon cans than for filling 5-ounce cups.

For the purpose of comparing the labor and equipment requirements for the two methods, the rate of freezing for each container size is the same for both methods. The freezing rates are 5-gallon and $2\frac{1}{2}$-gallon cans, 185 gallons per hour; gallon cartons, 140 gallons per hour; half-gallon and pint cartons, 100 gallons per hour; and 5-ounce and 3-ounce cups, 60 gallons per hour. It is also assumed that only one container size and one flavor will be filled at one time. Regardless of the method employed, all freezing operations are performed by one worker.

Three-tube method

The three-tube freezer (fig. 6) consists of three independent freezing tubes, each with a capacity of 100 gallons per hour. The maximum capacity of the freezer is 300 gallons per hour. Other items of equipment include a three-compartment flavor tank, each compartment having a capacity of 125 gallons of mix, a fruit feeder (fig. 7), two 6,000-pound-per-hour centrifugal pumps, and piping. Since the assumed rates for filling 5-gallon cans, $2\frac{1}{2}$-gallon cans, and gallon cartons are in excess of 100 gallons per hour, two tubes will be used when freezing for these containers. Smaller containers will require only one tube.

In the freezing of ice cream, mix is pumped from the storage vat to the flavor tank, flavor and coloring are added, mix is then pumped from the flavor tank through the freezer, and fruit is added to the ice cream as it leaves the freezer.

Flavor and coloring are added to each 125-gallon batch of mix, or four times for each 1,000 gallons of ice cream (1 gallon of mix is equivalent to 2 gallons of ice cream). As the mix begins to enter the tank, the worker starts the tank agitator and adds flavor and coloring to the mix.

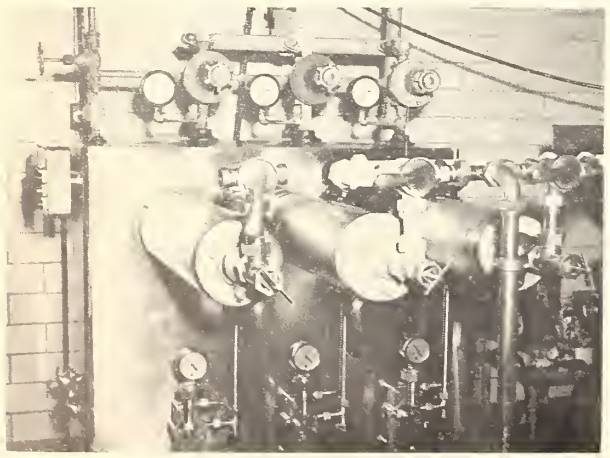

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FIGURE 6.—A three-tube freezer.

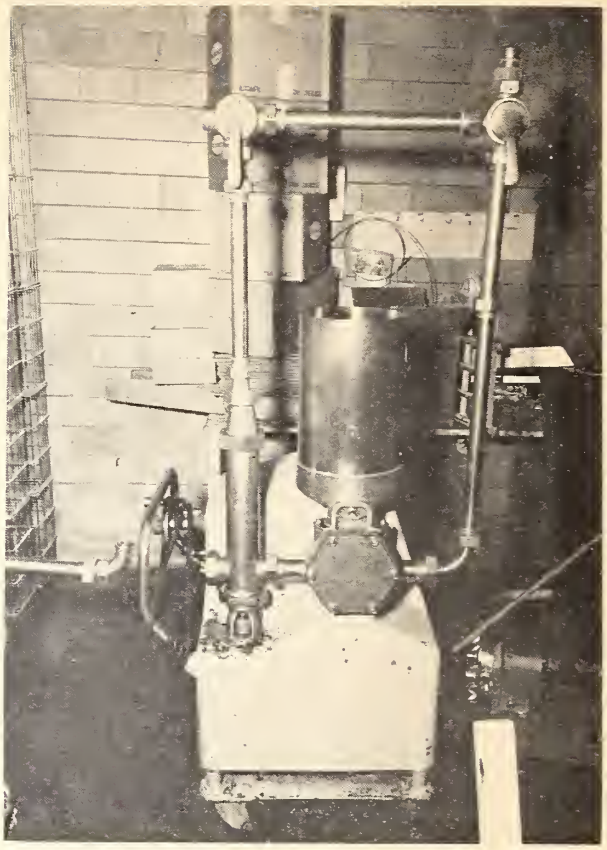

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FIGURE 7.—Fruit is added to the large hopper of the fruit feeder and forced into the ice cream. It is then uniformly mixed in the vertical mixing chamber to the left of the hopper.

Pumping mix through the freezer is completely automatic; the only labor is that required for setting up the freezer. Setting up involves the worker starting the pumps to pump ammonia into the accumulator of the freezer, which forces ice cream through the cylinder until the desired stiffness is obtained, and shutting down the freezer. Setups are required each time the freezer is started. Approximately four setups are required per 1,000 gallons of ice cream.

The fruit feeder is used for metering fruit, nuts or candy into the ice cream as it leaves the freezer. Since it is quite difficult to achieve and maintain the same conditions in two freezer tubes which are producing for a common package, the feeder is also used to blend the product of two tubes, or two freezers, and eliminate any color variation within the container.

The rate at which the fruit, nuts, or candy are fed into the ice cream varies for different products. On the average, however, fruits, nuts, or candy are added to the feeder hopper three times during the freezing of 1,000 gallons of ice cream. When the three-tube freezer method is employed for the

assumed plant, the feeder is used when 5-gallon cans, $2\frac{1}{2}$-gallon cans, gallon cartons, and a portion of the half-gallon and pint cartons are being filled.

Labor is required for setting up the freezer, the fruit feeder, and adding color and flavor. The number of setups varies by container sizes. Thus the labor requirements vary. Because of slower freezing rates, which result in greater machine utilization, equipment costs increase as container sizes are reduced. The requirements per 1,000 gallons for each container size when the three-tube method is employed are as follows:

Item	5- and $2\frac{1}{2}$-gallon cans		Gallon cartons		Half-gallon cartons		Pint cartons		5- and 3-ounce cups	
	Man-hours	*Cost*	*Man-hours*	*Cost*	*Man-hours*	*Cost*	*Man-hours*	*Cost*	*Man-hours*	*Cost*
Labor	3.56	$6.23	3.56	$6.23	2.02	$3.54	2.02	$3.54	1.54	$2.70
Equipment:	*Machine-hours*		*Machine-hours*		*Machine-hours*		*Machine-hours*		*Machine-hours*	
3-tube freezer	5.41	12.66	7.14	16.71	10.00	20.50	10.00	20.50	16.67	34.26
375-gallon flavor tank	6.18	1.60	7.91	2.05	10.77	2.79	10.77	2.79	17.44	4.51
Fruit feeder	5.41	3.47	7.14	4.59	4.32	2.77	4.48	2.88	-------	-------
$1\frac{1}{2}$-inch I.D. piping	.77	1.06	.77	1.06	.77	1.06	.77	1.06	.77	1.06
6,000-pound-per-hour centrifugal pump	.77	.35	.77	.35	.77	.35	.77	.35	.77	.35
Total	18.54	19.14	23.73	24.76	26.63	27.47	26.79	27.58	35.65	40.18
Total cost for labor and equipment	-------	25.37	-------	30.99	-------	31.01	-------	31.12	-------	42.88

On the basis of freezing 1,000 gallons of ice cream in all container sizes, in the ratio assumed for the plant manufacturing 150,000 gallons annually (table 1), the cost for the three-tube method is $30.39. The labor cost, which accounts for approximately 15 percent of the total cost, is $4.57. Since freezing is primarily a machine-controlled process, the equipment cost, $25.82 per 1,000 gallons, is the greatest portion of the total cost.

Single-tube method

The equipment employed in freezing ice cream by the single-tube method includes two single-tube freezers (fig. 8), each with a capacity of 150 gallons per hour; two 50-gallon flavor tanks (fig. 9); a fruit feeder; two 6,000-pound-per-hour centrifugal pumps; and piping. The two freezers operating together will freeze a maximum of 300 gallons of ice cream per hour. The use of two freezers and two flavor tanks provides an adequate freezing capacity, reduced changeover time, and flexibility when freezing two or more flavors for a common carton.

The method employed for freezing by the single-tube method is essentially the same as that described for the three-tube method. Since flavor tanks have a capacity of only 50 gallons, however,

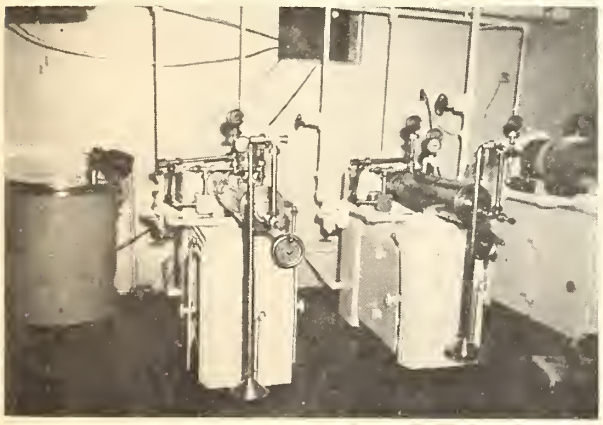

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FIGURE 8.—Single-tube freezers.

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FIGURE 9.—Individual flavor tanks feeding mix into ice cream freezers.

flavor and coloring must be added to the tanks 10 times for each 1,000 gallons of ice cream. With the single-tube method, the feeder is used only for 5- and $2\frac{1}{2}$-gallon cans and a portion of the half-gallon and pint cartons. Fruit, nuts, or candy are added to the feeder hopper approximately three times per 1,000 gallons of ice cream for both freezing methods.

Labor is required for setting up the freezer, for the fruit feeder, and for adding color and flavor. The labor requirements vary for different container sizes in the same manner as they did with the three-tube method. As with the three-tube method, equipment costs increase as the freezing rates and the container sizes decrease. This relationship, however, does not apply for 5- and $2\frac{1}{2}$-gallon cans since two freezers and two flavor tanks are required. The labor and equipment requirements per 1,000 gallons for freezing by the single-tube method are as follows:

Item	5- and $2\frac{1}{2}$-gallon cans		Gallon cartons		Half-gallon cartons		Pint cartons		5- and 3-ounce cups	
	Man-hours	*Cost*	*Man-hours*	*Cost*	*Man-hours*	*Cost*	*Man-hours*	*Cost*	*Man-hours*	*Cost*
Labor	4.10	$7.18	1.81	$3.17	2.29	$4.01	2.29	$4.01	1.81	$3.17
	Machine-hours		*Machine-hours*		*Machine-hours*		*Machine-hours*		*Machine-hours*	
Equipment:										
Two single-tube freezers	5.41	11.44								
One single-tube freezer			7.14	15.35	10.00	20.80	10.00	21.50	16.67	35.84
Two 50-gallon flavor tanks	6.18	1.50								
One 50-gallon flavor tank			7.91	1.98	10.77	2.58	10.77	2.69	17.44	4.36
Fruit feeder	5.41	5.32			4.32	4.25	4.48	4.40		
$1\frac{1}{2}$-inch I.D. piping	.77	.91	.77	.91	.77	.91	.77	.91	.77	.91
Two 6,000-pound-per-hour centrifugal pumps	.77	.35	.77	.35	.77	.35	.77	.35	.77	.35
Total	18.54	19.52	16.59	18.59	26.63	28.89	26.79	29.85	35.65	41.46
Total cost for labor and equipment		26.70		21.76		32.90		33.86		44.63

Freezing 1,000 gallons of ice cream for all container sizes, in the ratio shown in table 1, costs $29.62 with the single-tube method. The labor requirements are 2.45 man-hours, and the labor cost is $4.29. The equipment requirements are 23.12 machine-hours, and the equipment cost is $25.33. Labor costs account for about 14.5 percent of the total cost.

Comparison of the two methods

Freezing 1,000 gallons of ice cream for all container sizes, in the same ratio of production as assumed for the plant manufacturing 150,000 gallons annually (table 1), costs $30.39 with the three-tube method and $29.62 with the single-tube method.

With both methods, labor accounts for a small percentage of the total cost. The cost of adding flavor and coloring to the mix is less for the three-tube method because the large tank compartments require a less frequent turnover of mix batches. Labor costs are greater for adding fruit by the three-tube method because the more frequent use of the feeder increases the total feeder setup time. The cost of freezer setup is greater for the three-tube method because when ice cream is frozen for gallon cartons, two tubes of the three-tube freezer are required as opposed to one single-tube freezer. Equipment costs are approximately the same for both methods. In analyzing the freezer costs, it should be recalled that in neither case are the freezers fully utilized.

Packaging ice cream

The labor and equipment requirements for packaging ice cream vary widely for different types and sizes of containers. Therefore, the packaging of ice cream is analyzed on the basis of packaging ice cream in cans, in cartons, and in cups.

Packaging in cans

Ice cream is packaged in 5- and $2\frac{1}{2}$-gallon fiberboard cans. Ice cream in these sizes of containers is distributed almost exclusively to restaurants and soda fountains for the sale of dipped ice cream. The 5-gallon can measures approximately $9\frac{1}{4}$ inches in diameter by $18\frac{1}{2}$ inches in height. The $2\frac{1}{2}$-gallon can measures approximately $9\frac{1}{4}$ inches in diameter by $9\frac{1}{4}$ inches in height. Packaging bulk ice cream in cans involves forming cans and filling cans. Two methods are employed—the single-spindle, conveyor and the single-spindle, manual. Although the methods for handling 5- and $2\frac{1}{2}$-gallon cans are the same, labor and equipment requirements vary for the two sizes. Regardless

of the method employed or the size of can being packaged, only one worker is required.

The analysis of packaging operations is based on a plant packaging 4,420 gallons annually in 5-gallon cans, and 20,020 gallons in $2\frac{1}{2}$-gallon cans. As previously stated, the assumed rate for filling the cans is 185 gallons per hour.

Single-Spindle, Conveyor Method.—In the single-spindle, conveyor method, the worker uses a single-spindle can former to form the cans and moves the cans on a roller conveyor to fill, close, and label them.

The can former is a motor-driven device consisting of a spindle and a revolving crimper. It is adaptable for forming various sizes of containers having the same diameter. To form cans, the worker positions the side piece and top ring over the spindle, lowers the revolving crimper, and crimps top ring to side piece, raises crimper and inverts the can on the spindle, positions the bottom piece on the can, lowers crimper and crimps the bottom to the can, raises crimper, removes the can from the spindle, inverts the can and places it on a roller conveyor.

The conveyor is 12 feet long and extends from the can former to a belt conveyor leading into the hardening room. A filling device (fig. 10) is situated above the conveyor; a platform scale is installed in the conveyor (fig. 11) so that cans may be weighed with a minimum of labor; and a roller stamping device (fig. 12) is attached to the conveyor frame to automatically stamp the flavor and date on each can.

To fill cans, the worker pushes a can along the conveyor until it is directly beneath the filler, fills the can, places a lid on the can, weighs every tenth can to check the weight, and pushes the can onto the belt conveyor. While the can is being filled the worker forms cans.

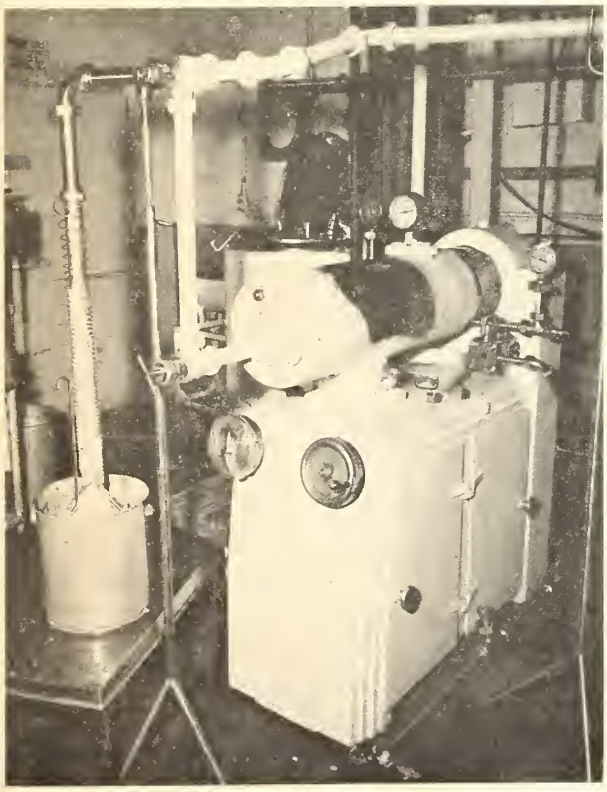

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FIGURE 10.—Cans are filled by a device attached to a freezer pipe.

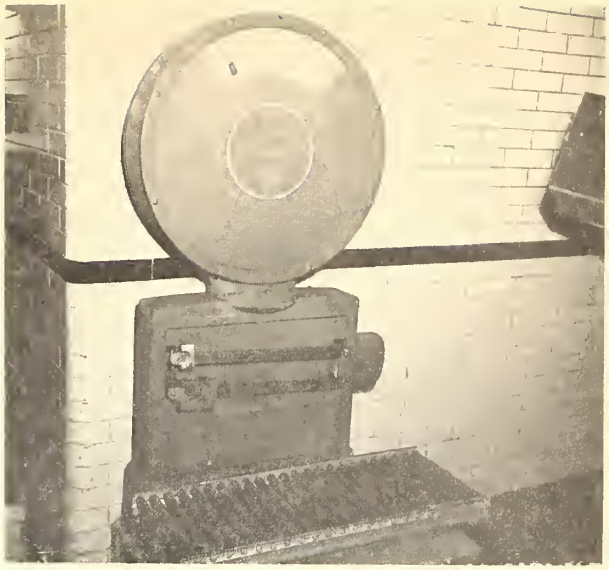

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FIGURE 11.—A scale-mounted conveyor section is inserted in the conveyor line to permit a continuous flow of cans with minimum handling.

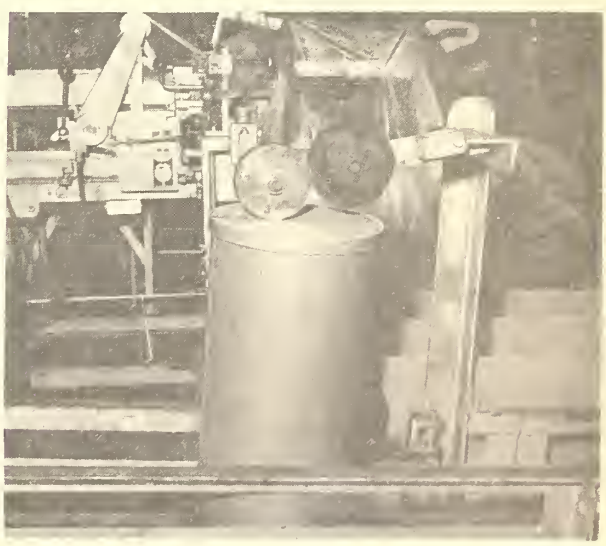

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FIGURE 12.—After the lid is positioned and the can weighed, the flavor is automatically rolled on by a stamping device.

The total labor and equipment requirements for packaging 1,000 gallons of ice cream in 5- and 2½-gallon cans with the single-spindle, conveyor method are as follows:

Item	5-gallon cans		2½-gallon cans	
	Man-hours	*Cost*	*Man-hours*	*Cost*
Labor	5.72	$10.01	6.84	$11.97
	Machine-hours		*Machine-hours*	
Equipment:				
Single-spindle can former	1.10	1.93	2.10	3.69
Platform scale	.01	.86	.02	1.73
Bulk filler	5.41	1.06	5.41	1.06
12-ft. roller conveyor	5.41	1.00	5.41	1.00
Can-stamping device	.08	.91	.15	1.71
1½-inch I.D. piping	5.41	.33	5.41	.33
Total	17.42	6.09	18.50	9.52
Total cost for labor and equipment		16.10		21.49

Included in the labor requirements for packaging ice cream in 5-gallon cans are 4.01 man-hours of machine-regulated wait time. This unproductive time is the result of worker waiting for the cans to fill. The labor requirements for filling 2½-gallon cans include 2.71 man-hours of waiting time. Both labor and equipment costs are greater for packaging 2½-gallon cans than for packaging 5-gallon cans. Labor costs are greater because more setups are required for packaging ice cream in 2½-gallon cans than in 5-gallon cans because of the ratios assumed in this report. Equipment costs are greater because more cans are formed, weighed, and stamped per 1,000 gallons of ice cream.

Single-Spindle, Manual Method.—In this method, the worker uses a single-spindle can former but moves the cans manually to fill, close, and label them. Cans are formed in the same manner as that described for the conveyor method. After being formed, however, the empty cans are placed on a worktable. To fill cans, the worker places an empty can on a pallet under the filler and a second empty can on the pallet near the filler; when the can is full, he replaces it with the empty can. He places the full can on a worktable, puts a lid on the can, stamps the flavor and date on the can with a hand stamp, weighs every tenth can on a table scale, and pushes the can to one side of the table. The worker forms cans while cans are being filled.

The labor and equipment requirements per 1,000 gallons for packaging ice cream in 5- and 2½-gallon cans with the single-spindle, manual method are as follows:

Item	5-gallon cans		2½-gallon cans	
	Man-hours	*Cost*	*Man-hours*	*Cost*
Labor	5.72	$10.01	6.84	$11.97
	Machine-hours		*Machine-hours*	
Equipment:				
Single-spindle can former	1.10	1.93	2.10	3.69
30- by 48-inch stainless steel worktable	.94	.03	1.76	.06
Bulk filler	5.41	1.06	5.41	1.06
Table scale	.01	.01	.04	.05
1½-inch I.D. piping	5.41	.26	5.41	.26
Total	12.87	3.29	14.72	5.12
Total cost for labor and equipment		13.30		17.09

Labor requirements included 3.17 man-hours of machine-regulated wait time in packaging 5-gallon cans and 1.14 man-hours in packaging 2½-gallon cans. This unproductive time is due to the worker's waiting for the cans to fill. As in the single-spindle, conveyor method, costs are higher for 2½-gallon cans because of increased setup time and a greater number of cans handled per 1,000 gallons.

Comparison of Methods.—A comparison of the two methods employed for packaging 5-gallon cans reveals that the labor costs are identical. Labor costs are also identical for the two methods of packaging 2½-gallon cans. The costs are the same because the filling rate, which determines the total labor requirement, is the same for both methods, and because in each case the productive labor requirements are less than the elapsed time required for filling the cans. Because of lower setup costs and fewer cans per 1,000 gallons of ice cream, the total labor and equipment cost for packaging 5-gallon cans is lower than that for packaging 2½-gallon cans, regardless of the method employed. The conveyor method is more costly than the manual method for packaging both container sizes because of the increased equipment cost incurred by the use of such items as a platform scale, a roller conveyor, and a can-stamping device (table 4).

Packaging in cartons

The majority of Indiana plants package ice cream in three carton sizes: gallon, half-gallon, and pint cartons. The volume of ice cream packaged in the various carton sizes at a particular plant depends upon the type of market outlet and local consumer buying practices. Whereas, some plants

TABLE 4.—*Packaging ice cream: Labor and equipment requirements and costs per 1,000 gallons in a plant manufacturing 150,000 gallons annually, by size of container and method of packaging* [1]

Method	Requirements		Costs		
	Labor	Equipment	Labor	Equipment	Total
	Man-hours	*Machine-hours*	*Dollars*	*Dollars*	*Dollars*
5-gallon cans:					
Single-spindle, conveyor method	5.72	17.42	10.01	6.09	16.10
Single-spindle, manual method	5.72	12.87	10.01	3.29	13.30
2½-gallon cans:					
Single-spindle, conveyor method	6.84	18.50	11.97	9.52	21.49
Single-spindle, manual method	6.84	14.72	11.97	5.12	17.09
Gallon cartons:					
Two-worker, manual	15.10	17.96	26.43	0.85	27.28
Spring table, manual	7.96	25.10	13.93	1.45	15.38
Spring table, chute, and basket	7.96	25.56	13.93	2.84	16.77
Two-worker, chute, and basket	15.10	18.42	26.43	2.25	28.68
Half-gallon cartons:					
Two-worker, chute, and basket	20.49	28.09	35.86	3.63	39.49
Three-worker, manual	30.49	27.39	53.36	1.43	54.79
Filler, manual	10.95	27.39	19.16	27.98	47.14
Filler, chute, and basket	10.95	28.09	19.16	30.16	49.32
Pint cartons:					
Filler, manual	13.28	28.68	23.24	53.08	76.32
Filler, chute, and basket	13.28	27.89	23.24	55.98	79.22
Four-worker, manual	41.30	28.68	72.28	1.85	74.13
Three-worker, chute, and basket	31.30	27.89	54.78	4.76	59.54
5-ounce cups:					
Four-worker, manual	67.54	33.80	118.20	1.98	120.18
Four-worker, basket	67.54	34.72	118.20	3.95	122.15
Filler, manual	19.77	48.23	34.60	199.56	234.16
Filler, basket	19.77	47.80	34.60	201.65	236.25
3-ounce cups:					
Two-worker, filler, manual	34.93	51.01	61.13	200.07	261.20
Two-worker, filler, basket	34.93	52.55	61.13	203.58	264.71
Five-worker, manual	83.80	34.29	146.65	2.41	149.06
Five-worker, basket	83.80	35.83	146.65	5.71	152.36

[1] For percentage of plant's volume packaged in each size of container, see table 1.

concentrate primarily on one container size, such as gallons, others package mostly pints, and still others package large quantities in each of the three carton sizes. The present analysis is based on a plant with an annual volume of 150,000 gallons, and packaging 37,440 gallons in gallon cartons, 60,372 gallons in half-gallon cartons, and 23,192 gallons in pint cartons. Labor and equipment requirements are based on freezing and filling rates of 140 gallons per hour for gallon cartons and 100 gallons per hour for half-gallon and pint cartons.

Packaging ice cream in cartons involves forming, filling, closing, weighing, and bagging cartons. There are two basic reasons for bagging containers: (1) to reduce the number of unit packages and (2) to keep the containers clean and free from fingermarks until they reach the point of consumer sale. Cartons are bagged in the following quantities: Gallon cartons, 2 per bag; half-gallon cartons, 2 per bag; and pint cartons, 8 per bag. When wire baskets are used for storing ice cream, the baskets contain 5 bags of gallon cartons or 6 bags of the smaller sizes.

Two types of cartons are used for packaging ice cream. One is used primarily for gallon packages; it has a preformed bottom and is formed manually. The other type is used for half-gallon and pint cartons and is designed for use with a packaging machine; it is precreased, but not preformed. If a plant does not use packaging machines, these cartons are formed manually (fig. 13).

Nine methods may be used for packaging ice cream in cartons. While six of the methods are used for packaging only one carton size, three methods are employed for packaging two sizes. The methods and the carton sizes packaged by each are as follows:

Method	*Carton size*
Two-worker, manual	Gallon
Spring-table, manual	Gallon
Spring-table, chute, and basket	Gallon
Two-worker, chute, and basket	Gallon and half-gallon
Three-worker, manual	Half-gallon
Filler, manual	Half-gallon and pint
Filler, chute, and basket	Half-gallon and pint
Four-worker, manual	Pint
Three-worker, chute, and basket	Pint

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FIGURE 13.—In the absence of a packaging machine, cartons are made up manually.

Two-Worker, Manual Method.—In packaging gallon cartons by this method, one worker stands beside the filling head attachment, picks up cartons, holds them under the attachment while they are being filled, then sets full cartons on the worktable. The second worker picks up, forms, and stacks empty cartons; closes and stacks full cartons; opens a bag, puts two cartons in it, and places it on the sealing table; closes and seals bags with paper tape; stamps the flavor and date on bags; weighs every tenth bag; and stacks bags on the table. The total labor and equipment requirements and costs per 1,000 gallons of ice cream are as follows:

	Man-hours	*Cost*
Labor	15.10	$26.43
	Machine-hours	
Equipment:		
Filling head attachment	7.14	0.10
1½-inch I.D. piping	7.14	.34
Table scale	.14	.19
Tape dispenser	.19	.11
30- by 48-inch stainless steel worktable	3.35	.11
Total	17.96	.85
Total cost for labor and equipment		27.28

Included in the labor requirements are 1.93 man-hours of machine-regulated wait time; the worker bagging cartons has to wait for the other worker to fill cartons.

Spring-Table, Manual Method.—One worker fills gallon cartons with ice cream by this method. The worker sits at a small table, which is placed under a filling device. Above the table, and attached to it, is a small platform on which the carton is placed for filling (fig. 14). The platform rests

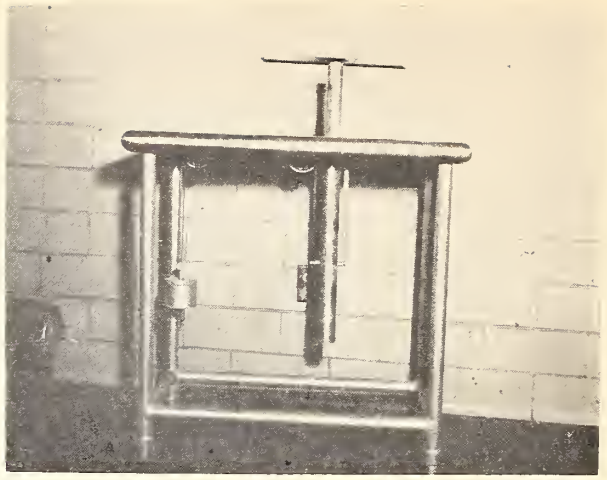

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FIGURE 14.—A carton is placed on the small platform above the table. As the carton is filled with ice cream from a filling device, the spring on which the platform rests allows the platform to descend slowly to the table.

on a spring, which allows the platform to descend slowly to the table as the carton fills with ice cream. When the carton is full, the worker replaces the full carton with an empty one.

While the carton is being filled, the worker forms empty cartons, closes full cartons, and bags, seals, weighs, and stamps them in the manner described for the two-worker, manual method (fig. 15).

The total labor and equipment requirements and costs, per 1,000 gallons of ice cream, for filling gallon cartons by this method are as follows:

	Man-hours	*Cost*
Labor	7.96	$13.93
	Machine-hours	
Equipment:		
Filling head attachment	7.14	0.10
12- by 18-inch spring table	7.14	.50
1½-inch I.D. piping	7.14	.43
Table scale	.14	.19
Tape dispenser	.19	.11
30- by 48-inch stainless steel worktable	3.35	.12
Total	25.10	1.45
Total cost for labor and equipment		15.38

Included in the labor requirements are 1.19 man-hours of machine-regulated wait time; the worker has to wait for the cartons to fill.

Spring-Table, Chute, and Basket Method.—One worker is required for this method. Cartons are filled in the manner described for the spring-table, manual method. In bagging cartons, however, the worker opens a bag, places it on a metal bagging chute, closes and tapes the bag, weighs every tenth bag, places the bags in a wire basket, and positions a new basket after every fifth bag. Printed sealing tape is used to eliminate manual bag stamping.

The total labor and equipment requirements and costs per 1,000 gallons for packaging ice cream in gallon cartons are as follows:

	Man-hours	*Cost*
Labor	7.96	$13.93
	Machine-hours	
Equipment:		
Filling head attachment	7.14	0.10
12- by 18-inch spring table	7.14	.50
1½-inch I.D. piping	7.14	.43
Table scale	.14	.19
30- by 48-inch stainless steel worktable	2.49	.12
Tape dispenser	.19	.11
87 wire baskets	.58	1.24
Bagging chute	.74	.15
Total	25.56	2.84
Total cost for labor and equipment		16.77

Included in the labor requirements are 1.47 man-hours of machine-regulated wait time; the worker has to wait for cartons to fill.

Two-Worker, Chute, and Basket Method.—When this method is employed, cartons are formed, filled, and closed in the same manner as in the two-worker, manual method and are bagged in the manner described for the spring-table, chute, and basket method.

The labor and equipment requirements and costs per 1,000 gallons of ice cream for packaging gallon and half-gallon cartons with this method are as follows:

Item	Gallon cartons		Half-gallon cartons	
	Man-hours	*Cost*	*Man-hours*	*Cost*
Labor	15.10	$26.43	20.49	$35.86
	Machine-hours		*Machine-hours*	
Equipment:				
Filling head attachment	7.14	0.10	10.00	0.13
1½-inch I.D. piping	7.14	.34	10.00	.47
Table scale	.14	.19	.28	.38
30- by 48-inch stainless steel worktable	2.49	.12	5.02	.24
Tape dispenser	.19	.11	.39	.23
87 wire baskets	.58	1.24		
231 wire baskets			.87	1.86
Bagging chute	.74	.15	1.53	.32
Total	18.42	2.25	28.09	3.63
Total cost for labor and equipment		28.68		39.49

Labor requirements include 2.21 man-hours of machine-regulated wait time for worker bagging

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FIGURE 15.—Worker forms empty cartons while waiting for filling device to fill gallon carton on platform. Platform descends slowly to the table as carton fills.

gallon cartons and 0.08 man-hours for the worker bagging half-gallon cartons; these workers have to wait while cartons are being filled.

Three-Worker, Manual Method.—In packaging ice cream in half-gallon cartons with this method, one worker picks up, forms, and stacks empty cartons and closes full cartons. A second worker holds empty cartons beneath the filling head attached to the freezer pipe. The third worker stands at table, opens a bag, inserts two cartons, places the bag on the table, closes and seals the bag with paper tape, stamps flavor and date on the bag, weighs every tenth bag, and stacks the bags on the table.

Labor and equipment requirements per 1,000 gallons of ice cream for packaging half-gallon cartons are as follows:

	Man-hours	*Cost*
Labor	30.49	$53.36
	Machine-hours	
Equipment:		
Filling head attachment	10.00	0.13
1½-inch I.D. piping	10.00	.47
30- by 48-inch stainless steel worktable	6.72	.22
Table scale	.28	.38
Tape dispenser	.39	.23
Total	27.39	1.43
Total cost for labor and equipment		54.79

Included in the labor requirements are 9.25 man-hours of machine-regulated wait time. This unproductive time is due to the workers who form and stack cartons having to wait for a worker to fill cartons.

Filler, Manual Method.—One worker packages ice cream in either half-gallon or pint cartons by this method. Cartons are formed and filled by an

automatic filling machine. One machine is designed specifically for half-gallon cartons (fig. 16), and another for pint cartons (fig. 17). Basically, the two machines are the same. The worker merely feeds flattened cartons into the carton track of the filler. The machine automatically forms the cartons, folds and locks the bottom flaps, fills the carton, folds and locks the top flaps, dates the carton, and discharges it. Cartons are bagged by the manual bagging method previously described.

The labor and equipment requirements and costs per 1,000 gallons for packaging ice cream with this method are as follows:

Item	Half-gallon cartons		Pint cartons	
	Man-hours	*Cost*	*Man-hours*	*Cost*
Labor	10.95	$19.16	13.28	$23.24
	Machine-hours		*Machine-hours*	
Equipment:				
Half-gallon filler	10.00	26.52	----	----
Pint filler	----	----	10.00	51.58
1½-inch I.D. piping	10.00	.61	10.00	.61
30- by 48-inch stainless steel worktable	6.72	.24	8.01	.28
Tape dispenser	.39	.23	0.39	.23
Table scale	.28	.38	.28	.38
Total	27.39	27.98	28.68	53.08
Total cost for labor and equipment	----	47.14	----	76.32

Labor requirements include 3.13 man-hours of machine-regulated wait time for the worker bagging half-gallon cartons and 1.54 man-hours for the worker bagging pint cartons; these workers have to wait while the machine fills the cartons.

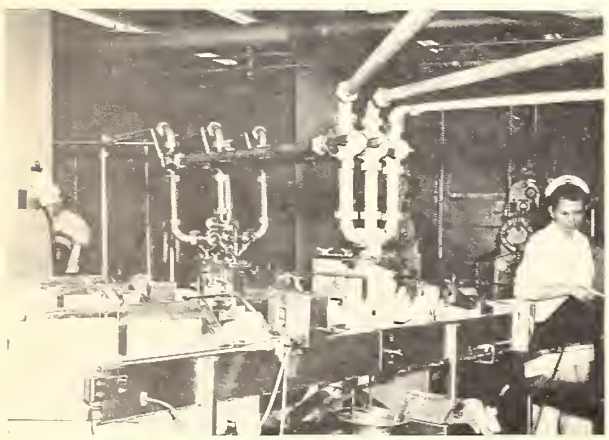

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FIGURE 16.—Worker loads flattened half-gallon cartons into the filling machine. The machine opens, fills, closes, and discharges the cartons into a bagging chute.

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FIGURE 17.—A machine for filling pint cartons.

Filler, Chute, and Basket Method.—One worker is required for packaging either half-gallon cartons or pint cartons by this method. Filling machines described for the previous method are employed, and cartons are bagged by the chute and basket method. The labor and equipment requirements per 1,000 gallons of ice cream for packaging half-gallon and pint cartons with this method are as follows:

Item	Half-gallon cartons		Pint cartons	
	Man-hours	*Cost*	*Man-hours*	*Cost*
Labor	10.95	$19.16	13.28	$23.24
	Machine-hours		*Machine-hours*	
Equipment:				
Half-gallon filler	10.00	26.52	----	----
Pint filler	----	----	10.00	51.58
1½-inch I.D. piping	10.00	.61	10.00	.61
30- by 48-inch stainless steel worktable	5.02	.24	4.92	.24
Tape dispenser	.39	.23	.39	.23
Table scale	.28	.38	.28	.38
Bagging chute	1.53	.32	1.43	1.08
231 wire baskets	.87	1.86	----	----
89 wire baskets	----	----	.87	1.86
Total	28.09	30.16	27.89	55.98
Total cost for labor and equipment	----	49.32	----	79.22

Labor requirements include 3.96 man-hours of machine-regulated wait time for packaging half-gallon cartons and 3.76 man-hours for pint cartons because worker bagging cartons has to wait for cartons to be filled.

Four-Worker, Manual Method.—Use of this method requires four workers, three for forming and filling pint cartons and one for bagging. One

worker forms and stacks empty cartons. A second worker holds cartons beneath the filling head while they are being filled. The third worker closes and stacks full cartons. The fourth worker bags cartons in the manner previously described for manual bagging. The following are the labor and equipment requirements and costs per 1,000 gallons of ice cream:

	Man-hours	*Cost*
Labor	41.30	$72.28
	Machine-hours	
Equipment:		
Filling head attachment	10.00	.50
1½-inch I.D. piping	10.00	.47
30- by 48-inch stainless steel worktable	8.01	.27
Tape dispenser	.39	.23
Table scale	.28	.38
Total	28.68	1.85
Total cost for labor and equipment		74.13

The labor requirements include 7.91 man-hours of machine-regulated wait time; workers forming, closing, and bagging cartons have to wait for the worker to fill cartons.

Three-Worker, Chute, and Basket Method.—Pint cartons are formed and filled by this method in the same manner as that described for the four-worker, manual method. Cartons are bagged in the same way as in the filler, chute, and basket method. Workers who form and close cartons do the bagging during their wait time. The labor and equipment requirements per 1,000 gallons of ice cream are as follows:

	Man-hours	*Cost*
Labor	31.30	$54.78
	Machine-hours	
Equipment:		
Filling head attachment	10.00	.50
1½-inch I.D. piping	10.00	.47
30- by 48-inch stainless steel worktable	4.92	.24
Tape dispenser	.39	.23
Table scale	.28	.38
Bagging chute	1.43	1.08
89 wire baskets	.87	1.86
Total	27.89	4.76
Total cost for labor and equipment		59.54

Included in the labor requirements for packaging pint cartons is 0.13 man-hour of machine-regulated wait time for the worker closing cartons.

Comparison of Methods.—The lowest cost method for packaging in gallons is the spring-table, manual method which requires only one worker. The spring-table, chute, and basket method, which also requires one worker, is slightly higher because of the cost of a bagging chute and 87 wire baskets. The two other methods each require two workers, and the total costs are almost double the total costs of the methods which utilize a spring table for filling. The two-worker, chute, and basket method, the highest cost method, incurs a slightly higher cost than the two-worker, manual method because of the use of a bagging chute and baskets. The spring-table, manual method incurs the least amount of machine-regulated wait time among the four methods, and the two-worker, chute, and basket method incurs the greatest amount.

The lowest cost method of packaging half-gallon cartons is the two-worker, chute, and basket method, and this method incurs the least amount of machine-regulated wait time. Because of relatively high labor costs, the three-worker, manual method is the most expensive method, and requires more machine-regulated wait time than any other method. Although the use of a filler reduces the crew size to one worker, the equipment costs are considerably higher than for either of the other two methods. The cost of a bagging chute and 231 wire baskets makes the filler, chute, and basket method slightly more expensive than the filler, manual method.

The three-worker, chute, and basket method is the least expensive method of packaging pint cartons, and it incurs the least amount of machine-regulated wait time. Because of higher labor costs, the four-worker, manual method incurs a considerably higher cost than the three-worker, chute, and basket method. This method requires the greatest amount of machine-regulated wait time. The filler, chute, and basket method requires only one worker, but the high equipment cost, due primarily to the cost of the filler, makes it the most expensive method. The filler, manual method, which also utilizes one worker, costs slightly less than the filler, chute, and basket method (table 4).

Packaging in cups

Most plants handle two sizes of cups, 5-ounce and 3-ounce; a few package ice cream in 3½-ounce cups. Although a wide variety of flavors are packaged in cups, many plants package only vanilla ice cream in cups because of the cost of setting up equipment for a variety of flavors. This analysis is based on packaging only vanilla flavor in 5-ounce and 3-ounce cups. The cups are filled at a rate of 60 gallons per hour and bagged in units of 2 dozen. Included in each bag are 2 dozen prepacked wooden spoons.

Eight methods may be used for packaging ice cream in cups:

Method	*Cup size*
Four-worker, manual	5 ounce
Four-worker, basket	5 ounce
Filler, manual	5 ounce
Filler, basket	5 ounce
Two-worker, filler, manual	3 ounce
Two-worker, filler, basket	3 ounce
Five-worker, manual	3 ounce
Five-worker, basket	3 ounce

Four-Worker, Manual Method.—Five-ounce cups are packaged by four workers in the following manner: One worker holds cups beneath a filling spout to fill them, placing a full cup on the table while the next cup fills; a second worker presses a lid on each cup, and pushes the cup aside; the third worker seats lids firmly in the cups with a circular wooden block which he holds in his hand, and pushes the cup aside; and the fourth worker puts 2 dozen cups and 2 dozen wooden spoons in a bag, moves the bag along the table, closes and tapes the bag, stamps it, weighs every tenth bag, and stacks the bags on the table.

The labor and equipment requirements and costs per 1,000 gallons of ice cream for packaging 5-ounce cups with this method are as follows:

	Man-hours	*Cost*
Labor	67.54	$118.20
	Machine-hours	
Equipment:		
1½-inch I.D. piping	16.67	.79
30- by 48-inch stainless steel work-table	16.43	.55
Tape dispenser	.41	.24
Table scale	.29	.40
Total	33.80	1.98
Total cost for labor and equipment		120.18

The labor requirements include 4.84 man-hours of machine-regulated wait time; three workers wait for the worker filling cups.

Four-Worker, Basket Method.—Cups are filled and capped in the same manner as that used for the four-worker manual method. To bag cups, a worker puts 2 dozen cups and spoons in a bag, moves bag along the table, closes the bag and seals it with printed tape, weighs every tenth bag, stacks bags in baskets (6 bags per basket), and positions empty baskets.

The following are the labor and equipment requirements per 1,000 gallons of ice cream for packaging 5-ounce cups with this method:

	Man-hours	*Cost*
Labor	67.54	$118.20
	Machine-hours	
Equipment:		
1½-inch I.D. piping	16.67	.79
30- by 48-inch stainless steel work-table	16.43	.55
Tape dispenser	.41	.24
Table scale	.29	.40
12 wire baskets	.92	1.97
Total	34.72	3.95
Total cost for labor and equipment		122.15

Included in the labor requirements is a total of 5.27 man-hours of machine-regulated wait time for the second, third, and fourth workers, whose pace is regulated by the filling rate.

Filler, Manual Method.—This method is based on the use of a cup filling and capping machine (fig. 18), which is adaptable for cups ranging in capacity from 2½ ounces to 1 quart. Cups and lids are manually loaded into hoppers (fig. 19). The machine automatically fills, caps, and discharges the cups. To package in 5-ounce cups one worker adds cups and lids to the filler hoppers and bags cups in the manner described for manual bagging.

The labor and equipment requirements per 1,000 gallons of ice cream for packaging 5-ounce cups are as follows:

	Man-hours	*Cost*
Labor	19.77	$34.60
	Machine-hours	
Equipment:		
Cup filling and capping machine	16.67	197.41
1½-inch I.D. piping	16.67	1.01
30- by 48-inch stainless steel work-table	14.19	.50
Tape dispenser	.41	.24
Table scale	.29	.40
Total	48.23	199.56
Total cost for labor and equipment		234.16

The labor requirements include 0.16 man-hour of machine-regulated wait time as a result of the worker waiting for the machine.

Filler, Basket Method.—The filler, basket method may be employed for packaging in 5-ounce cups. One worker is required. Cups are filled in the same manner as that employed by the filler, manual method and are bagged in the manner described for the four-worker, basket method.

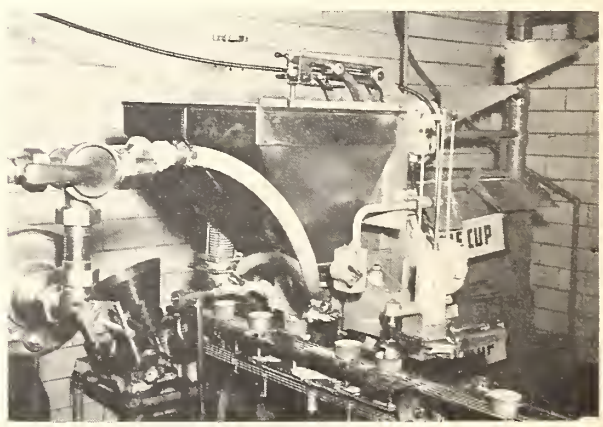

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FIGURE 18.—This filler automatically feeds, fills, caps, and discharges cups.

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FIGURE 19.—Worker adds a box of 50 empty cups to the hopper of the cup filler.

The following are the labor and equipment requirements per 1,000 gallons of ice cream:

	Man-hours	*Cost*
Labor	19.77	$34.60
	Machine-hours	
Equipment:		
Cup filling and capping machine	16.67	197.41
1½-inch I.D. piping	16.67	1.01
30- by 48-inch stainless steel worktable	12.84	.62
Tape dispenser	.41	.24
Table scale	.29	.40
12 wire baskets	.92	1.97
Total	47.80	201.65
Total cost for labor and equipment		236.25

The labor requirements include 0.59 man-hours of machine-regulated wait time because the worker is required to wait for the filler.

Two-Worker, Filler, Manual Method.—To package in 3-ounce cups with this method, two workers are required. One worker adds cups and lids to the hoppers. A cup-filling machine automatically fills, caps, and discharges the cups. A second worker opens bags, places cups and spoons in them, and pushes full bags aside. The first worker closes, tapes, stamps, weighs, and stacks the bags.

The labor and equipment requirements per 1,000 gallons of ice cream for packaging in 3-ounce cups are as follows:

	Man-hours	*Cost*
Labor	34.93	$61.13
	Machine-hours	
Equipment:		
Cup filling and capping machine	16.67	197.41
1½-inch I.D. piping	16.67	1.01
30- by 48-inch stainless steel worktable	16.49	.58
Tape dispenser	.69	.40
Table scale	.49	.67
Total	51.01	200.07
Total cost for labor and equipment		261.20

The labor requirements include 4.52 man-hours of machine-regulated wait time because both workers have to wait for the filler.

Two-Worker, Filler, Basket Method.—Packaging 3-ounce cups with this method requires two workers. Cups are filled in the manner previously described for the filler, manual method. The method of bagging is the same as that described for the four-worker, basket method of bagging 5-ounce cups.

The labor and equipment requirements per 1,000 gallons of ice cream for packaging in 3-ounce cups are as follows:

	Man-hours	*Cost*
Labor	34.93	$61.13
	Machine-hours	
Equipment:		
Cup filling and capping machine	16.67	197.41
1½-inch I.D. piping	16.67	1.01
30- by 48-inch stainless steel worktable	16.49	.79
Tape dispenser	.69	.40
Table scale	.49	.67
11 wire baskets	1.54	3.30
Total	52.55	203.58
Total cost for labor and equipment		$264.71

The labor requirements include 5.24 man-hours of machine-regulated wait time because the workers have to wait for the filler.

Five-Worker, Manual Method.—The following procedure is employed when packaging 3-ounce cups by the five-worker, manual method: One worker fills cups by holding them beneath a filling device and places a full cup on the table while filling another; a second worker puts lids on cups and pushes the cups aside; two workers seat lids firmly in the cups with round wooden blocks, and one of these workers utilizes his wait time to close, tape, stamp, weigh and stack bags on table; the fifth worker adds cups and spoons to a bag, and pushes the bag along the table.

The labor and equipment requirements per 1,000 gallons for packaging ice cream in 3-ounce cups are as follows:

	Man-hours	*Cost*
Labor	83.80	$146.65

	Machine-hours	Cost
Equipment:		
30- by 48-inch stainless steel worktable	16.44	0.55
Tape dispenser	.69	.40
Table scale	.49	.67
1½-inch I.D. piping	16.67	.79
Total	34.29	2.41
Total cost for labor and equipment		149.06

The labor requirements include 1.01 man-hours of machine-regulated wait time because 3 workers wait for the worker filling cups.

Five-Worker, Basket Method.—To package in 3-ounce cups by this method, cups are filled and lids are placed and seated as described for the five-worker, manual method. In addition to seating lids, one worker closes and tapes bags, weighs every tenth bag, stacks bags in baskets, and positions empty baskets. The fifth worker opens bags, adds cups and spoons and pushes the bag aside.

The labor and equipment requirements per 1,000 gallons of ice cream are as follows:

	Man-hours	Cost
Labor	83.80	$146.65
	Machine-hours	Cost
Equipment:		
30- by 48-inch stainless steel worktable	16.44	0.55
Tape dispenser	.69	.40
Table scale	.49	.67
1½-inch I.D. piping	16.67	.79
11 wire baskets	1.54	3.30
Total	35.83	5.71
Total cost for labor and equipment		152.36

The labor requirements include 1.73 man-hours of machine-regulated wait time because three workers wait for the worker filling cups.

Comparison of Methods.—The lowest cost method of packaging in 5-ounce cups is the four-worker, manual method. The cost of the four-worker, basket method is slightly higher because of the cost of baskets and because it requires more machine-regulated wait time than any other. Although only one worker is required, the cost of the filler, manual method (filling and capping cups by machine) is almost double that of the manual methods of filling cups. The filler, manual requires the least amount of machine-regulated wait time. The high cost of the method is due entirely to the cost of a filling and capping machine. The filler, basket method, the highest cost method, costs slightly more than the filler, manual method because of the additional cost of wire baskets.

The lowest cost method of packaging in 3-ounce cups is the five-worker, manual method, which incurs less machine-regulated wait time than any other. The method incurring the greatest cost and the greatest amount of machine-regulated wait time is the two-worker, filler, basket method. Primarily as a result of the high cost of the filling and capping machine, the filler methods cost considerably more than the manual methods of filling cups. The use of baskets causes a slight increase in packaging costs (table 4).

Summary of packaging operations

Ice cream packaging operations are summarized on the basis of labor and equipment requirements for packaging 1,000 gallons of ice cream in all container sizes according to the previously described production ratio. The operations are also summarized for two combinations of methods.

Combination A is based on packaging 5- and 2½-gallon cans by the single-spindle, conveyor method; gallon cartons by the two-worker, manual method; half-gallon and pint cartons and 5-ounce cups by the filler, manual method; and 3-ounce cups by the two-worker, filler, manual method.

Combination B is based on packaging 5- and 2½-gallon cans by the single-spindle, manual method; gallon cartons by the spring-table, chute, and basket method; half-gallon cartons by the two-worker, chute, and basket method; pint cartons by the three-worker, chute, and basket method; 5-ounce cups by the four-worker, chute, and basket method; and 3-ounce cups by the five-worker, chute, and basket method.

The labor and equipment cost for packaging is $48.32 per 1,000 gallons of ice cream with combination A methods and $35.98 with combination B methods (table 5). Thus costs are reduced $12.34 per 1,000 gallons by using combination B methods. The primary cause of the cost difference is the lower equipment costs with combination B methods. These methods do, however, require a greater labor cost than combination A methods. Equipment costs with combination A methods are relatively high because plants manufacturing a small volume find it difficult to utilize high-cost equipment efficiently.

Storing ice cream

During the packaging process ice cream is in a semifrozen state. The final process involved in its manufacture is reducing the temperature of the product until it is solidly frozen. This process, known as "hardening," takes place in a low-temperature (−10° to −30° F.) hardening room. Ice cream is stored in the hardening room until it is loaded out for delivery. The length of time required to harden ice cream depends upon room temperature, package size, stacking arrangement, room ventilation, type of refrigeration system (fig. 20), and other related factors. It is assumed, however, that ice cream is hardened overnight at most plants.

TABLE 5.—*Packaging ice cream: Labor and equipment requirements and costs per 1,000 gallons in a plant manufacturing 150,000 gallons annually, by combination of packaging methods* [1]

Combination of methods	Requirements		Costs		
	Labor	Equipment	Labor	Equipment	Total
	Man-hours	*Machine-hours*	*Dollars*	*Dollars*	*Dollars*
A methods [2]	12.07	24.41	21.13	27.19	48.32
B methods [3]	18.38	25.41	32.17	3.81	35.98

[1] For percentage of volume packaged in each size of container, see table 1.

[2] Packaging 5- and 2½-gallon cans with the single-spindle, conveyor; gallon cartons with the two-worker, manual; half-gallon and pint cartons and 5-ounce cups with the filler, manual; and 3-ounce cups with the two-worker, filler, manual method.

[3] Packaging 5- and 2½-gallon cans with the single-spindle, manual; gallon cartons with the spring table, chute, and basket; half-gallon cartons with the two-worker, chute, and basket; pint cartons with the three-worker, chute, and basket; 5-ounce cups with the four-worker, basket; and 3-ounce cups with the five-worker, basket method.

Storing is analyzed on the basis of storing ice cream packaged in 5- and 2½-gallon cans and in cartons and cups.

Storing cans

Storing 5- and 2½-gallon cans of ice cream involves transporting cans from the packaging area to the hardening room and stacking them on floor pallets. Two methods are employed for storing cans—the manual method and the conveyor method. Each method requires only one worker.

Manual Method.—The cans are carried from the packaging area to the coldroom port, and placed on the port ledge inside the hardening room (fig. 21). They are then carried approximately 20 feet and stacked on floor racks. Because of their size and weight, 5-gallon cans are handled individually. However, 2½-gallon cans are usually handled two at a time. The worker usually places six 5-gallon cans or twelve 2½-gallon cans on the ledge before going into the hardening room to stack them.

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FIGURE 20.—A typical blower used for refrigerating hardening rooms.

The labor required per 1,000 gallons for storing either size of can is 1.84 man-hours, and the labor cost is $3.22. No equipment is involved in the operation.

Conveyor Method.—Storing 5- and 2½-gallon cans by the conveyor method involves transferring cans singly from the packaging table to the hardening room conveyor, walking an average distance of 20 feet into the hardening room when the conveyor accumulates twelve 5-gallon cans or twenty-four 2½-gallon cans, removing cans singly from the conveyor and stacking them on pallets approximately 6 feet away, and returning to the packaging room. The method employed in storing is the same for both sizes of can. Labor requirements vary, however, since 1,000 gallons of ice cream in 2½-gallon cans require twice as many cans and

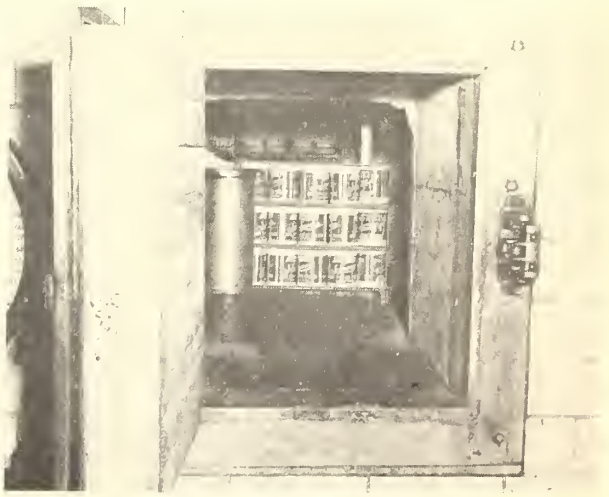

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FIGURE 21.—Coldroom port between packaging room and hardening room has a ledge inside the hardening room. Worker in the packaging room places containers of ice cream on the ledge. When the ledge is full, he goes into the hardening room and stores the ice cream on shelves.

twice as much handling as 5-gallon cans. The labor and equipment requirements for storing cans are as follows:

Item	5-gallon cans		$2\frac{1}{2}$-gallon cans	
	Man-hours	*Cost*	*Man-hours*	*Cost*
Labor	0.45	$0.79	0.90	$1.58
	Machine-hours		*Machine-hours*	
Equipment:				
34-foot belt conveyor	5.41	.65	5.41	.65
Total cost		1.44		2.23

Comparison of Methods.—Storing cans of ice cream costs $3.22 per 1,000 gallons for both can sizes when the manual method is employed (table 6). If the conveyor method is employed, the cost per 1,000 gallons is $1.44 for 5-gallon cans and $2.23 for $2\frac{1}{2}$-gallon cans. Equipment costs for the conveyor method are identical for both can sizes. Labor requirements and costs per 1,000 gallons are twice as high, however, for $2\frac{1}{2}$-gallon cans because twice as many cans of this size are handled.

Storing cartons and cups

As previously stated, all cartons and cups of ice cream are stored in paper bags. The bags are then transported into the hardening room and stacked. The number of bags required for 1,000 gallons of ice cream are as follows: 500 bags for gallon cartons; 1,000 bags for half-gallon cartons; 1,000 bags for pint cartons; 1,064 bags for 5-ounce cups; and 1,786 bags for 3-ounce cups.

When baskets are used for storing bags, one basket contains 5 bags of gallon cartons or 6 bags of all other cartons and cups. As a result of the variation in quantity per bag, labor and equipment costs are different for storing two container sizes by the same method.

Four methods are employed for storing cartons and cups. They are the double-stack, conveyor and basket, manual, and conveyor methods. Each method requires one worker.

Double-Stack Method.—The double-stacking method involves transporting bags of ice cream from the packaging table to the hardening room conveyor, walking an average distance of 15 feet

TABLE 6.—*Storing ice cream: Labor and equipment requirements and costs per 1,000 gallons in a plant manufacturing 150,000 gallons annually, by size of container and method of storing* [1]

Method	Requirements		Costs		
	Labor	Equipment	Labor	Equipment	Total
	Man-hours	*Machine-hours*	*Dollars*	*Dollars*	*Dollars*
5-gallon cans:					
Manual	1.84		3.22		3.22
Conveyor	.45	5.41	.79	0.65	1.44
$2\frac{1}{2}$-gallon cans:					
Manual	1.84		3.22		3.22
Conveyor	.90	5.41	1.58	.65	2.23
Gallon cartons:					
Double-stack	1.58	8.16	2.77	1.59	4.36
Basket and conveyor	.59	7.66	1.03	1.89	2.92
Manual	1.26		2.21		2.21
Conveyor	.75	7.14	1.31	.86	2.17
Half-gallon or pint cartons:					
Double-stack	3.17	11.71	5.55	2.43	7.98
Basket and conveyor	1.17	10.87	2.05	2.94	4.99
Manual	2.52		4.41		4.41
Conveyor	1.50	10.00	2.62	1.21	3.83
5-ounce cups:					
Double-stack	3.37	18.49	5.90	3.31	9.21
Basket and conveyor	1.25	17.60	2.19	3.86	6.05
Manual	2.68		4.69		4.69
Conveyor	1.59	16.67	2.78	2.01	4.79
3-ounce cups:					
Double-stack	5.66	19.71	9.91	4.17	14.08
Basket and conveyor	2.09	18.22	3.66	5.09	8.75
Manual	4.50		7.88		7.88
Conveyor	2.67	16.67	4.67	2.01	6.68

[1] For percentage of volume packaged in each container size, see table 1.

into the hardening room, transferring bags from the conveyor to wire baskets, and stacking the baskets 6-high on pallets. The following morning, after the ice cream has hardened, the baskets are removed from the bags and dumped on the conveyor, empty baskets are stacked, bags are conveyed approximately 7 feet and closely stacked on pallets. This method is often employed since ice cream hardens more rapidly in baskets than in closely packed stacks. The method is also used to compensate for space limitations when room size prohibits the storing of bags in loose stacks. The labor and equipment requirements per 1,000 gallons for each container size are as follows:

Item	Gallon cartons		Half-gallon or pint cartons	
	Man-hours	*Cost*	*Man-hours*	*Cost*
Labor	1.58	$2.77	3.17	$5.55
	Machine-hours		*Machine-hours*	
Equipment:				
34-foot belt conveyor	7.14	0.86	10.00	1.21
100 wire baskets	1.02	.73		
167 wire baskets			1.71	1.22
Total	8.16	1.59	11.71	2.43
Total cost for labor and equipment		$4.36		7.98

Item	5-ounce cups		3-ounce cups	
	Man-hours	*Cost*	*Man-hours*	*Cost*
Labor	3.37	$5.90	5.66	$9.91
	Machine-hours		*Machine-hours*	
Equipment:				
34-foot belt conveyor	16.67	2.01	16.67	2.01
178 wire baskets	1.82	1.30		
298 wire baskets			3.04	2.16
Total	18.49	3.31	19.71	4.17
Total cost for labor and equipment		9.21		14.08

Basket and Conveyor Method.—To store ice cream by this method, bags of ice cream are placed in baskets at the worktable by the bagging worker. The baskets are then placed on a belt conveyor, which takes them into the hardening room (fig. 22); they are removed from the conveyor and stacked on pallets (fig. 23). Bags remain in the baskets until they are ready for loading out. The labor and equipment requirements per 1,000 gallons for each container size are as follows:

Item	Gallon cartons		Half-gallon or pint cartons	
	Man-hours	*Cost*	*Man-hours*	*Cost*
Labor	0.59	$1.03	1.17	$2.05
	Machine-hours		*Machine-hours*	
Equipment:				
34-foot belt conveyor	7.14	0.86	10.00	1.21
100 wire baskets	.52	1.03		
167 wire baskets			.87	1.73
Total	7.66	1.89	10.87	2.94
Total cost for labor and equipment		2.92		4.99

Item	5-ounce-cups		3-ounce cups	
	Man-hours	*Cost*	*Man-hours*	*Cost*
Labor	1.25	$2.19	2.09	$3.66
	Machine-hours		*Machine-hours*	
Equipment:				
34-foot belt-conveyor	16.67	2.01	16.67	2.01
178 wire baskets	.93	1.85		
298 wire baskets			1.55	3.08
Total	17.60	3.86	18.22	5.09
Total cost for labor and equipment		6.05		8.75

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FIGURE 22.—The conveyor transports bags directly from the packaging room into the hardening room.

Manual Method.—Storing bags by this method involves picking up 4 bags and transporting them approximately 6 feet to the hardening room ledge, walking approximately 20 feet into the hardening room after 48 bags have accumulated on the ledge, transferring bags approximately 20 feet to a storage shelf, and returning to the packaging room. Since all work is performed manually, no equipment is required for this method. The labor requirements per 1,000 gallons of each container size are as follows:

Gallon cartons, 1.26 man-hours, cost $2.21; half-gallons or pints, 2.52 man-hours, cost $4.41; 5-ounce cups, 2.68 man-hours, cost $4.69; and 3-ounce cups, 4.50 man-hours, cost $7.88.

Conveyor Method.—When the conveyor method is employed, bags of cartons and cups are transferred directly from the packaging table onto the belt conveyor and conveyed into the hardening room. The bags are then removed from the conveyor and stacked on shelves. Baskets are not employed with this method. The labor and equipment requirements per 1,000 gallons of ice cream in each container size are as follows:

Item	Gallon cartons		Half-gallon or pint cartons	
	Man-hours	*Cost*	*Man-hours*	*Cost*
Labor	0.75	$1.31	1.50	$2.62
	Machine-hours		*Machine-hours*	
Equipment:				
34-foot belt conveyor	7.14	.86	10.00	1.21
Total cost for labor and equipment		2.17		3.83
	5-ounce cups		3-ounce cups	
	Man-hours	*Cost*	*Man-hours*	*Cost*
Labor	1.59	$2.78	2.67	$4.67
	Machine-hours		*Machine-hours*	
Equipment:				
34-foot belt conveyor	16.67	2.01	16.67	2.01
Total cost for labor and equipment		4.79		6.68

Comparison of Methods.—The lowest cost method for storing gallon, half-gallon, or pint cartons and 3-ounce cups is the conveyor method (table 6). The next lowest cost method is the manual method. The manual method is the only method of the four employed for storing these containers in which no equipment is used. Thus, the relatively high labor cost incurred with the manual method is offset because no equipment cost is involved. The highest cost method is the double-stack. The relatively high cost of this method is due to the large amount of labor required.

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FIGURE 23.—A worker stacks baskets in the hardening room.

The lowest cost method for storing 5-ounce cups is the manual method. The manual method has a high labor cost but no equipment cost. The conveyor method has a relatively low labor cost, but this is offset by the comparatively high equipment cost. The double-stack method is the highest cost method.

The most efficient method of storing may not necessarily be the lowest cost method because the method used in storing is determined by the method of packaging. Furthermore, the method of packaging also determines the method of loading out. For example, if cartons and cups are placed in baskets in the packaging operation, they should be stored and loaded out in baskets. Therefore, the most efficient method of storing is the method that, when combined with packaging and loading out, results in the lowest total cost.

Summary of storing operations

Storing operations are summarized on the basis of labor and equipment requirements for storing 1,000 gallons of ice cream in all container sizes in the same ratio as assumed for the plant manufacturing 150,000 gallons annually (table 1). The operations are compared for two combinations of methods. In combination "A" 5- and $2\frac{1}{2}$-gallon cans are stored by the conveyor method and all other containers by the double-stack method. In combination "B" 5- and $2\frac{1}{2}$-gallon containers are stored by the conveyor method and all other containers by the basket and conveyor method. Both combination A and B methods take into consideration methods of packaging and also loading out.

The cost for storing 1,000 gallons of ice cream packaged in all container sizes is $6.21 with combination A methods and $4.05 with combination B methods (table 7). The reduction in cost with combination B methods is in the labor cost. The labor cost with combination A methods is $4.23 and with combination B methods $1.71. The lower labor cost is the result of using the basket, conveyor method, which eliminates handling bags twice with the double-stack method.

TABLE 7.—*Storing ice cream: Labor and equipment requirements and costs per 1,000 gallons in a plant manufacturing 150,000 gallons annually, by combinations of methods* [1]

Combination	Requirements		Costs		
	Labor	Equipment	Labor	Equipment	Total
	Man-hours	*Machine-hours*	*Dollars*	*Dollars*	*Dollars*
A methods [2]	2.42	10.01	4.23	1.98	6.21
B methods [3]	0.98	9.38	1.71	2.34	4.05

[1] For percentage of volume packaged in each container size, see table 1.
[2] Storing 5- and 2½-gallon cans by the conveyor method, and all other containers by the double-stack method.
[3] Storing 5- and 2½-gallon cans by the conveyor method, and all other containers by the basket and conveyor method.

Loading out ice cream

Ice cream is loaded directly from the hardening room into refrigerated trucks for shipment to customers. The trucks may be either conventional 4-wheel dairy trucks for local small-order customers, or semitrailer trucks for large-order or out-of-town customers. Since the trucks are refrigerated they can be loaded during the day or night, but the loading usually takes place during the normal plant workday. Work crews for loading out vary, but as a rule the truck driver arranges and stacks ice cream in the truck. Work performed by the truck driver is not included in plant labor requirements for loading out ice cream.

The operation is analyzed on the basis of loading out ice cream packaged in 5- and 2½-gallon cans and in cartons and cups.

Loading out cans

Loading out cans involves transporting cans from the storage location in the hardening room to the load-out port. The load-out port, which also serves as a conveyor port, is comparable to the port connecting the packaging room and the hardening room. In this case, a small stacking ledge is situated outside the port. Two methods are commonly employed for loading out cans—the manual method and the conveyor method. In each case, only one worker is involved.

Manual Method.—Worker carries one 5-gallon can or two 2½-gallon cans at a time from the storage site to the load-out port, an average of 15 feet, and stacks them for the truck loader. No equipment is involved in the operation. Labor required for loading out 1,000 gallons in either can size equals 0.57 man-hour, and the labor cost is $1.

Conveyor Method.—When the conveyor method is used, cans are carried from the stacks to the conveyor and are conveyed to the load-out port. Cans of both sizes are placed individually on the conveyor. The labor requirements and cost per 1,000 gallons of ice cream for loading out cans by the conveyor method are as follows:

Five-gallon cans, 0.20 man-hour, the cost $0.35; 2½-gallon cans, 0.37 man-hours, the cost $0.65. The equipment requirements based on the use of a 34-foot belt conveyor is 0.20 machine-hour for 5-gallon cans and 0.37 machine-hour for 2½-gallon cans. The equipment cost is less than one cent for both container sizes.

Comparison of Methods.—The cost of loading out 1,000 gallons of ice cream in either size of can by the manual method is $1. The cost for loading out by the conveyor method is $0.35 for 5-gallon cans and $0.65 for 2½-gallon cans. Since equipment cost is less than one cent, it is not included. The variation in labor costs for the two can sizes results from the fact that both 5- and 2½-gallon cans are handled individually (table 8).

Loading out cartons and cups

Cartons and cups are loaded out in bags. The bags may or may not be in baskets. The bags are moved to the load-out port manually or by conveyor. Since the truck driver loads bags at the rate of 0.75 man-hour per 1,000 gallons of ice cream, the load-out worker cannot maintain a faster pace. Three methods are employed for loading out cartons and cups—manual, basket and conveyor, and conveyor. In each case, one worker is required.

Basket and Conveyor Method.—This method involves removing baskets from the stacks in the hardening room and transporting them an average of 6 feet to the conveyor, emptying bags of ice cream from the baskets onto the conveyor, and

TABLE 8.—*Loading out ice cream: Labor and equipment requirements and costs per 1,000 gallons in a plant manufacturing 150,000 gallons annually, by size of container and method* [1]

Method	Requirements		Costs		
	Labor	Equipment	Labor	Equipment	Total
	Man-hours	*Machine-hours*	*Dollars*	*Dollars*	*Dollars*
5-gallon cans:					
Manual	0.57	----------	1.00	----------	1.00
Conveyor	.20	0.20	.35	(2)	.35
2½-gallon cans:					
Manual	.57	----------	1.00	----------	1.00
Conveyor	.37	.37	.65	(2)	.65
Gallon cartons:					
Basket and conveyor	.44	1.12	.77	0.46	1.23
Manual	.56	----------	.98	----------	.98
Conveyor	.51	.87	.89	(2)	.89
Half-gallon or pint cartons:					
Basket and conveyor	.87	1.36	1.52	.76	2.28
Manual	1.10	----------	1.93	----------	1.93
Conveyor	1.01	.87	1.77	(2)	1.77
5-ounce cups:					
Basket and conveyor	.93	1.40	1.63	.81	2.44
Manual	1.17	----------	2.05	----------	2.05
Conveyor	1.06	.87	1.86	(2)	1.86
3-ounce cups:					
Basket and conveyor	1.56	1.84	2.73	1.35	4.08
Manual	1.96	----------	3.43	----------	3.43
Conveyor	1.78	.87	3.12	(2)	3.12

[1] For percentage of volume packaged in each container size, see table 1.
[2] Cost is less than one cent per 1,000 gallons.

stacking and moving empty baskets. Although the operation requires only 0.55 man-hour per 1,000 gallons, the load-out worker must wait 0.20 man-hour to allow the driver sufficient time for loading the truck. Labor and equipment requirements per 1,000 gallons are as follows:

Item	Gallon cartons		Half-gallon or pint cartons		Item	5-ounce cups		3-ounce cups	
	Man-hours	*Cost*	*Man-hours*	*Cost*		*Man-hours*	*Cost*	*Man-hours*	*Cost*
Labor	0.44	$0.77	0.87	$1.52	Labor	0.93	$1.63	1.56	$2.73
	Machine-hours		*Machine-hours*			*Machine-hours*		*Machine-hours*	
Equipment:					Equipment:				
34-foot belt conveyor	0.75	(1)	0.75	(1)	34-foot belt conveyor	.75	(1)	.75	(1)
100 wire baskets	.37	0.46	----------	----------	178 wire baskets	.65	.81	----------	----------
167 wire baskets	----------	----------	.61	0.76	298 wire baskets	----------	----------	1.09	1.35
Total	1.12	.46	1.36	.76	Total	1.40	.81	1.84	1.35
Total cost for labor and equipment	----------	1.23	----------	2.28	Total cost for labor and equipment	----------	2.44	----------	4.08

[1] Equipment cost is less than $0.01 per 1,000 gallons.

Manual Method.—Loading out bags by the manual method involves transporting bags (4 at a time) an average distance of 15 feet from the stacking shelf to the load-out ledge, stacking bags on the ledge, and returning to the storage shelf. No equipment is required when this method is employed. Labor requirements and cost per 1,000 gallons of ice cream are as follows:

Gallon cartons, 0.56 man-hour, $0.98; half-gallon or pint cartons, 1.10 man-hours, $1.93; 5-ounce cups, 1.17 man-hours, $2.05; and 3-ounce cups, 1.96 man-hours, $3.43.

Conveyor Method.—Loading out bags by the conveyor method involves picking up 4 bags from stack, carrying bags an average of 4 feet to the outgoing conveyor, placing bags on the conveyor, and returning to the stack. Labor requirements and cost per 1,000 gallons of ice cream for each container size are as follows:

Gallon cartons, 0.51 man-hour, $0.89; half-gallon or pint cartons, 1.01 man-hours, $1.77; 5-ounce cups, 1.06 man-hours, $1.86; and 3-ounce cups, 1.78 man-hours, $3.12. The equipment requirements based on the use of a 34-foot belt conveyor for 0.87 machine-hour for each container size is less than one cent.

Comparison of Methods.—The lowest cost method of loading out gallon, half-gallon, and pint cartons and 5- and 3-ounce cups is the conveyor method (table 8). The highest cost method of the three used is the basket and conveyor method. Although the labor cost for this method is the lowest, it has a relatively high equipment cost.

Summary of loading out operations

Loading out operations are summarized on the basis of labor and equipment requirements for loading out 1,000 gallons of ice cream according to the ratio of container sizes previously described. The operations are compared for two combinations of methods. Combination A methods involve loading out all containers by the conveyor method, whereas combination B methods involve loading out by the conveyor and the basket and conveyor methods. The labor cost is less for combination B methods due to the use of baskets. However, the total costs are $1.76 for combination B methods and $1.37 for combination A methods (table 9). The difference in cost is due to relatively high equipment cost.

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FIGURE 24.—Machine parts are scrubbed and placed on a worktable for the hot-water rinse.

Cleaning manufacturing equipment

All equipment that comes into contact with ice cream or ice cream ingredients is cleaned at the end of each workday. Large plants often employ a crew to clean the equipment at night. At small or medium-sized plants, however, the production workers clean all equipment in the afternoon immediately after completing the manufacturing operations. Cleaning usually involves dismantling, washing, rinsing, and steaming the equipment and parts (figs. 24 and 25). Certain items, such as freezers, vats, pumps, and some of the piping, are usually reassembled immediately after being cleaned. Other items, such as the filling machine, are usually reassembled the following day.

Other than brushes and buckets, which are not considered in this analysis, only two items of cleaning equipment are required for cleaning purposes. A centrifugal pump, which is also used as the pasteurizer pump, is employed for circulating cleaning solutions through the H.T.S.T. pasteurizer and the homogenizer. A vat approximately 11

TABLE 9.—*Loading out ice cream: Labor and equipment requirements and costs per 1,000 gallons in a plant manufacturing 150,000 gallons annually, by combination of methods* [1]

Combination of methods	Requirements		Costs		
	Labor	Equipment	Labor	Equipment	Total
	Man-hours	*Machine-hours*	*Dollars*	*Dollars*	*Dollars*
A methods [2]	0.80	0.79	1.37	[4]	1.37
B methods [3]	.69	1.15	1.19	0.57	1.76

[1] For percentage of volume packaged in each container size, see table 1.
[2] Loading out all containers by the conveyor method.
[3] Loading out 5- and 2½-gallon cans by the conveyor method, and all other containers by the basket and conveyor method.
[4] Cost is less than one cent.

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FIGURE 25.—A worker scrubs the inside of a vat with a long-handled brush.

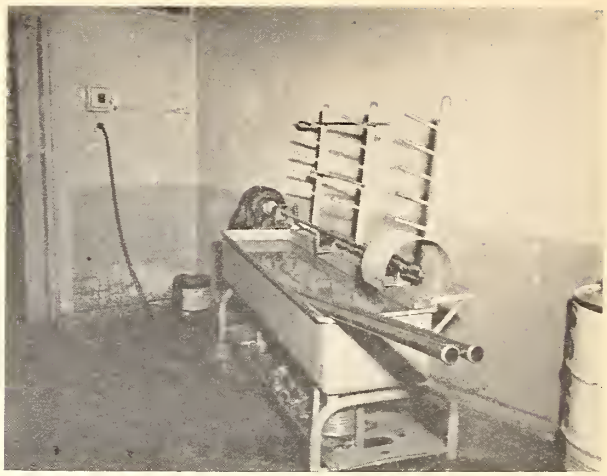

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FIGURE 26.—Piping is rinsed in the vat, scrubbed by a revolving brush (inside the splash shield), placed on the storage racks, and rinsed with a hose.

feet long, 2 feet wide, and 1 foot deep (fig. 26) is used for washing piping. Horizontally along the top of the vat is a revolving brush attached to a 10- to 12-foot pipe through which cleaning solutions are pumped. A storage rack for clean pipe is attached to the back of the vat. No equipment is required for cleaning other items of equipment.

At most plants the first step involves cleaning the pipe, because removing all pipe from the manufacturing area facilitates the cleaning of other items. The clean piping is then stored on the rack until all other items have been cleaned, or until the following morning.

The method used and the labor and equipment required for cleaning a particular item of equipment are essentially the same in all plants studied. However, the requirements for cleaning different items of equipment vary widely. For the purposes of this analysis, the plant equipment is divided into two types:

Type 1 equipment is used with the combination A methods: Receiving mix ingredient by the bulk handtruck method; preparing mix by the bulk and H.T.S.T. method; freezing with the three-tube freezer; and packaging 5- and $2\frac{1}{2}$-gallon cans by single-spindle, conveyor method, gallon cartons by the two-worker, manual method, half-gallon and pint cartons and 5-ounce cups by filler, manual method, and 3-ounce cups by the two-worker filler manual method.

Type 2 equipment is used with the combination B methods: Receiving ingredients by the can and handtruck method; preparing mix by the can and batch method; freezing by single-tube freezer; and packaging 5- and $2\frac{1}{2}$-gallon cans by the single-spindle, manual method, gallon cartons by the spring-table, chute, and basket method, half-gallon cartons by the two-worker, chute, and basket method, pint cartons by the three-worker, chute, and basket method, 5-ounce cups by the four-worker, basket method, and 3-ounce cups by the five-worker, basket method.

Cleaning type 1 equipment

The items of type 1 equipment and the labor requirements for cleaning each item are shown in table 10. The homogenizer, the pasteurizer, and the pasteurizing pump are cleaned by circulating

TABLE 10.—*Cleaning manufacturing equipment: Labor requirements per 1,000 gallons of ice cream for cleaning type 1 equipment in a plant manufacturing 150,000 gallons annually* [1]

Equipment	Labor requirements
	Man-hours
600-gallon cream tank	0.87
600-gallon skim milk tank	.87
Six 6,000-lb.-per-hr. centrifugal pumps	.24
50-gallon weigh tank	.33
300-gallon mix tank	.48
10,000-lb.-per-hr. centrifugal pump	.10
5,400-lb.-per-hr. H.T.S.T. pasteurizer	.28
600-gallon-per-hr. homogenizer	.10
600-gallon mix storage vat	.87
300-gallon mix storage vat	.44
375-gallon flavor tank	.41
300-gallon-per-hr. 3-tube freezer	2.15
Fruit feeder	.53
Half-gallon filling machine	.57
Pint filling machine	.53
Cup filling machine	.87
Bulk filler	.25
30- by 48-inch stainless steel worktable	.01
Piping	2.85
Total	12.75

[1] Based on a plant manufacturing 150,000 gallons annually and performing operations with combination A methods.

cleaning solution through them. All other items of equipment are cleaned manually.

The labor cost for cleaning type 1 equipment is $22.32. The cost for using a circulatory cleaning pump for 2.09 machine-hours and a pipe-washing vat for 0.85 machine-hour, a total of 2.94 machine-hours, is $0.80. The total labor and equipment cost per 1,000 gallons of ice cream for cleaning type 1 equipment is $23.12.

Cleaning type 2 equipment

The items of type 2 equipment and the labor requirements for cleaning each item are shown in table 11. All items of equipment are cleaned manually.

TABLE 11.—*Cleaning manufacturing equipment: Labor requirements per 1,000 gallons of ice cream for cleaning type 2 equipment in a plant manufacturing 150,000 gallons annually* [1]

Equipment	Labor requirements
	Man-hours
50-gallon weigh tank	0.33
Three 6,000-lb.-per-hr. centrifugal pumps	.12
300-gallon pasteurizing vat	.73
600-gallon-per-hr. homogenizer	1.13
5,400-lb.-per-hr. plate cooler	3.29
600-gallon mix storage vat	.87
300-gallon mix storage vat	.44
Two 50-gallon flavor tanks	.32
Two 150-gallon-per-hr. single-tube freezers	3.68
Fruit feeder	.53
Bulk filler	.25
Spring filling table	.01
Two bagging chutes	.04
30- by 48-inch stainless steel worktable	.01
Piping	1.39
Total	13.14

[1] Based on a plant manufacturing 150,000 gallons of ice cream annually and performing operations with combination B methods.

The labor cost for cleaning type 2 equipment is $23.01. The cost for using a pipe-washing vat for 0.44 machine-hour is $0.53. The total labor and equipment cost per 1,000 gallons of ice cream for cleaning type 2 equipment is $23.54.

Summary of requirements for cleaning equipment

The total cost per 1,000 gallons of ice cream for cleaning type 1 ice cream manufacturing equipment is $23.12 and for cleaning type 2 equipment $23.54. Labor constitutes about 97 percent of the total cost for cleaning both types of equipment. The cost differs primarily because several items of type 1 equipment are cleaned by circulatory methods, whereas all items of type 2 equipment are cleaned manually.

Summary of requirements for ice cream plant operations

The total cost per 1,000 gallons of ice cream in a plant manufacturing 150,000 gallons annually is $149.22 with combination A methods and $125.53 with combination B methods (table 12). The difference amounts to $23.69 per 1,000 gallons. On an annual basis the difference would amount to approximately $3,600.

All of the reduction in cost with combination B methods is in the equipment cost; labor cost is about 19 percent higher for combination B methods. The equipment cost is $90.66 with combination A methods and $55.65 with combination B methods.

Equipment costs with combination B methods are lower for plants of this size because manual methods are more economical than methods requiring relatively high-cost labor-saving equipment. The increased labor cost incurred by the manual methods used with combination B is more than offset by the reduction in equipment costs. This relationship results in overall economy for combination B methods for plants of this size.

Combination B methods result in savings in all operating cycles except loading out ice cream and cleaning equipment. The greatest saving, $12.34 is in the packaging operations, and is due to the fact that most containers are filled manually rather than by high-cost filling machines. Other significant savings, $5.54 for receiving ingredients and $3.69 for preparing mix, are the result of reduced equipment costs.

LAYOUT FOR AN ICE CREAM PLANT

The primary purpose in plant designing is to provide facilities for performing all plant operations in the most efficient manner. In designing an ice cream plant, therefore, at least five factors should be considered: (1) Proposed distribution of container sizes and of flavors, (2) estimated production, (3) paths of flow, (4) space requirements, and (5) future expansion.

Both the distribution of container sizes and flavors and the sales forecasts must be determined by management before the design of a plant can be initiated. On the basis of annual production estimates, equipment types and sizes and space requirements can be determined.

Paths of flow are of primary importance in the design of an efficient plant. Flow patterns must be determined for ingredients, products, and containers. Thus, equipment should be arranged to provide the most direct flow of ingredients and products. At the same time, the various work areas

TABLE 12.—*Summary of labor and equipment requirements and costs per 1,000 gallons of ice cream in a plant manufacturing 150,000 gallons annually, by combination of methods and major operating cycle* [1]

Operating cycle	Combination A methods [2]					Combination B methods [3]				
	Requirements		Costs			Requirements		Costs		
	Labor	Equipment	Labor	Equipment	Total	Labor	Equipment	Labor	Equipment	Total
	Man-hours	*Machine-hours*	*Dollars*	*Dollars*	*Dollars*	*Man-hours*	*Machine-hours*	*Dollars*	*Dollars*	*Dollars*
Receiving mix ingredients	0.53	117.80	0.93	5.09	6.02	0.25	0.25	0.44	0.04	0.48
Preparing mix	2.29	127.46	4.01	29.78	33.79	4.04	126.30	7.07	23.03	30.10
Freezing ice cream	2.61	24.88	4.57	25.82	30.39	2.45	23.12	4.29	25.33	29.62
Packaging ice cream	12.07	24.41	21.13	27.19	48.32	18.38	25.41	32.17	3.81	35.98
Storing ice cream	2.42	10.01	4.23	1.98	6.21	.98	9.38	1.71	2.34	4.05
Loading out ice cream	.80	.79	1.37	(4)	1.37	.69	1.15	1.19	.57	1.76
Cleaning equipment	12.75	2.94	22.32	.80	23.12	13.14	.44	23.01	.53	23.54
Total	33.47	308.29	58.56	90.66	149.22	39.93	186.05	69.88	55.65	125.53

[1] For percentage of volume packaged in each container size, see table. 1

[2] Receiving mix ingredients by the bulk handtruck method; preparing mix by the bulk and H.T.S.T. method; freezing ice cream by the 3-tube freezer method; packaging 5- and 2½-gallon cans by the single-spindle, conveyor method, gallon cartons by the two-worker, manual method, half-gallon and pint cartons and 5-ounce cups by the filler, manual method, and 3-ounce cups by the two-worker, filler, manual method; storing cans by the conveyor method and cartons and cups by the double-stack method; loading out all containers by the conveyor method and cleaning all equipment utilized by these methods.

[3] Receiving mix ingredients by the can and handtruck method; preparing mix by the can and batch method; freezing ice cream by the single-tube freezer method; packaging 5- and 2½-gallon cans by the single-spindle manual method, gallon cartons by the spring table, chute, and basket method, half-gallon cartons by the two-worker chute and basket method, pint cartons by the three-worker chute and basket method, 5-ounce cups by the four-worker basket method, and 3-ounce cups by the five-worker basket method; storing cans by the conveyor method and cartons and cups by the basket and conveyor method; loading out cans by the conveyor method and cartons and cups by the basket and conveyor method, and cleaning all equipment utilized by these methods.

[4] Cost is less than one cent per 1,000 gallons.

should be located to provide a direct flow of products and supplies through the plant and to reduce the distance traveled by workers.

Space requirements for operational areas should be based on the types and sizes of equipment, plus the additional space required for working aisles and for equipment cleaning. All equipment requiring frequent cleaning should be located at least 3 feet from walls and other items of equipment if adequate space is to be provided for cleanup work. Storage room dimensions should be based on the size and quantity of stored materials, the average turnover of materials, and the necessary aisle space.

When the plant is being designed, consideration should be given to future expansion. As a rule, the rooms primarily affected by an increase in volume are the hardening room, the dry storage room, and the machinery room. These rooms should adjoin one another along an outside wall, so that expansion will require the removal of only one outside wall.

Operators of ice cream plants planning the construction of new plants or the revision of existing plants should consult engineers and health department officials for assistance in preparing actual plant designs.

Proposed layout for a plant

To illustrate the major principles of layout for an ice cream plant, a proposed layout for a 150,000 gallon a year plant is shown in figure 27.

The plant is designed for receiving fluid ingredients in cans and dry ingredients in 100-pound sacks; preparing mix by the can and batch method; freezing ice cream with the single-tube freezer method; packaging cans with the single-spindle, manual method, gallon cartons with the spring-table, chute, and basket method, half-gallon and pint cartons with the chute and basket method, and cups with the basket method; storing cans by the conveyor method, cartons and cups by the basket and conveyor method; and loading out cans by the conveyor method and cartons and cups by the basket and conveyor method.

The proposed plant measures 71 feet 3 inches by 70 feet, and comprises 4,987.5 square feet. Of this area, the main office accounts for 800 square feet, and the plant proper comprises 4,187.5 square feet. The major components of the plant are as follows: A can storage cooler, a mix area, a freezing and packaging area, a hardening room, and a dry storage room. Auxiliary areas include a machinery room, the production manager's office, the laboratory, the locker room, and the main office.

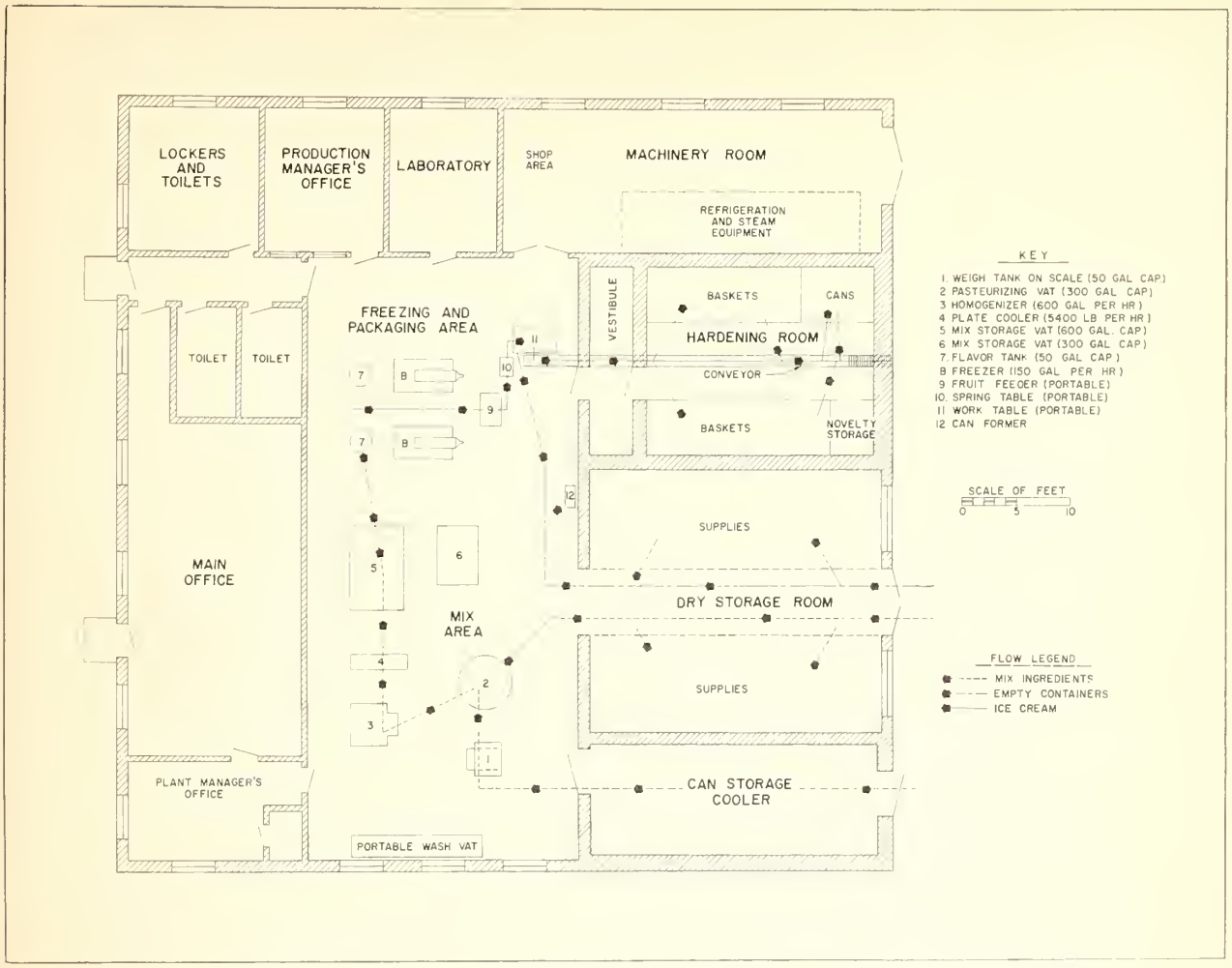

FIGURE 27.—Proposed layout for an ice cream plant manufacturing 150,000 gallons annually. Arrows show the flow of mix ingredients, empty containers, and ice cream through the plant.

Can storage cooler

The can storage cooler is used for storing 10-gallon cans of cream and skim milk, and empty cans. The room should be impervious to moisture and should be insulated to maintain a temperature of approximately 35° F. The size of a can storage cooler for an ice cream plant should be based on (1) volume of skim milk and cream to be stored, (2) pattern of receipts, (3) length of storage period, (4) method of stacking cans, and (5) amount of aisle space needed.

The volume of skim milk and cream stored should be directly related to the amount of ice cream produced. Production information for Indiana shows that a plant manufacturing 150,000 gallons annually produces 24 percent of its total production during July and August. The average weekly production during this period is 4,157 gallons. Approximately 610 gallons of cream and 720 gallons of skim milk would be needed for this production. Based on receiving cream and skim milk twice a week and receiving 40 percent of the weekly supply at one time and 60 percent at another, storage would be needed for 80 full cans and 53 empty cans. If full cans are stored side by side and 1.2 square feet of space is allowed per can, the storage requirements for full cans would amount to 96 square feet.

The storage space requirements for empty cans stacked two high is about 32 square feet. The total space needed for storing cans of cream and skim milk and empty cans is 128 square feet.

An aisle 4 feet wide should extend through the center of the room to allow space for a 2-wheel handtruck to be used for transporting cans into and out of the room. The suggested aisle contains about 106 square feet. Thus, the total space requirements amount to 234 square feet.

A room 26 feet 5 inches long and 10 feet wide is suggested for the can storage cooler. The room

contains about 264 square feet of space. Thirty square feet of the space, above the requirements for cans and an aisle, could be used at the receiving door for maneuvering the 4-wheel handtruck or to permit an aisle between the cans of cream and the cans of skim milk.

Full cans should be stacked side by side and empty cans two high. All cans should be placed on floor storage racks to allow periodic cleaning of the room. Floors should be slightly sloped toward drains, so that the room remains free of moisture. Room should be refrigerated by blower units.

Mix area

The mix area houses all equipment for assembling, processing, and storing ice cream mix. To insure a direct flow of mix ingredients (fig. 27), the mix area is situated between the can storage cooler and the freezing and packaging area.

Layout of Area.—The mix area is 24 feet 9 inches by 30 feet. Since outside traffic is discouraged in the mix area, there is no direct entrance from outside the building. Visitors, however, may enter the plant through the main office and past the production manager's office. Walls should be of a light color, and should be easily cleaned and impervious to moisture. Floors should be capable of supporting the weight of all equipment. They should be surfaced with a material that is impervious to moisture and cleaning acids, and resistant to wear or to chipping. Lighting, both natural and artificial, should provide a minimum intensity of 10 foot-candles throughout the room. The room should be ventilated to maintain a dust-free atmosphere and to eliminate moisture on the ceiling. Floors should be adequately sloped toward drains, and all drains should be placed to keep aisles and working areas free of puddles.

Arrangement of Equipment.—Equipment in the mix area is arranged to provide a straight flow of ingredients from the can storage cooler to the ice cream freezers. A weigh tank supported on a scale is located 7 feet from the cooler to allow space for maneuvering a 4-wheel handtruck. Cans are dumped into the weigh tank from the side nearest the can cooler. They are then rinsed, replaced on the handtruck, and returned to the cooler. All other items of equipment are located no less than 3 feet apart. Both pipe footage and walking distance between machines should be held to a minimum, but sufficient space should be allowed between items of equipment to permit adequate cleaning. All items of equipment should be at least 4 feet from the outer wall, allowing the portable wash vat to be moved along the entire length of the wall and providing working space at the wash vat.

Freezing and packaging area

The freezing and packaging area houses freezers, flavor tanks, a fruit feeder and all packaging equipment. Since there is a relatively continuous flow of mix from the mix area to the freezing and packaging area, these work areas are located in the same room.

Layout of Area.—The area is 24 feet 9 inches by 24 feet in size. The requirements for lighting, floor construction, and wall surface should be the same as those recommended for the mix area.

Arrangement of Equipment.—Flavor tanks and freezers are situated next to the storage vats for the mix to minimize the length of piping required. The flavor tanks are located 4 feet from the wall and 2 feet from the freezers. These are the only items of stationary equipment in the area. The fruit feeder, the worktable, and the spring table are all portable and may be stored against the side wall when not in use. Space is provided between the freezers and the conveyor, so that equipment can be rolled into position as needed. A can former is located along the wall of the dry storage room to allow one worker to form and fill cans with a minimum of travel.

Hardening room

The hardening room is used for hardening semi-frozen ice cream, and for storing ice cream and certain perishable ingredients. The size of a hardening room should be based on (1) the volume of ice cream stored, (2) the estimated length of the storage period, (3) the number of flavors and the container sizes in which ice cream is packaged, (4) the amount of ice cream stored per bag and the number of bags per basket, (5) the amount of space required for storing perishable ingredients, (6) the amount of aisle space needed, and (7) the method of stacking baskets.

To insure adequate storage space the volume to be stored should be based on the average weekly production during peak production periods. As previously stated, the peak production for a plant manufacturing 150,000 gallons annually would be 4,157 gallons a week. The estimated length of storage would be 1 week. The plant would produce five flavors and package ice cream in seven container sizes. In storing ice cream, baskets can be stacked six high, 5-gallon cans three high, and 2½-gallon cans five high. A stack of baskets occupies 1.67 square feet of floor space and a stack of cans 0.6 square feet.

Storing 678 gallons of ice cream packed in 5- and 2½-gallon cans and 3,479 gallons in baskets would require 189 square feet of space. It is suggested that about 20 square feet of space be provided for storing novelties purchased from outside sources. Thus, total space needed for storing ice cream manufactured by the plant and novelties purchased from outside sources is 209 square feet. Conveyor and aisle space should be provided, and a vestibule for storing perishable items such as fruits, nuts, candy, and syrups is also suggested.

Layout of Room.—The hardening room should be adjacent to the freezing and packaging area so that packages may be moved only a short distance to storage. The suggested hardening room measures 26 feet by 17 feet and has 425 square feet of usable space. It contains a vestibule measuring 4 feet by 17 feet, which should be insulated to maintain a temperature of 35° F. The vestibule would be used for storing such perishable items as fruits, nuts, candy, and syrups, and for reducing the effect of temperature changes when the door to the hardening room is opened. The vestibule should be adjacent to the freezing and packaging area.

The hardening and storing area measures 21 feet by 17 feet. Two storage spaces 5 feet in width extend along the full-length of the area and are separated by a 1-foot-wide conveyor with 3-foot working aisles on each side. The storage area contains 210 square feet. The aisle and conveyor occupy 147 square feet of space. The area is purposely designed with long, narrow storage spaces to minimize the distance between stacks of ice cream and the conveyor, and to minimize labor requirements for storing and loading out.

All items will be stored in the order in which they appear on the load-out sheet. Thus the worker will begin loading the conveyor at the outer wall and will move back through the room. Such a system minimizes the distance traveled by the worker and reduces the waiting time caused by the conveyor filling up. Refrigeration losses due to unnecessary traffic are eliminated by not having an outside door in the room.

Arrangement of Equipment.—The only item of handling equipment required is a conveyor. The conveyor is 12 inches wide, approximately 20 inches high, and 34 feet long. It consists of 30 feet of belt conveyor and 4 feet of roller conveyor. The roller section, which extends inward from the load-out port, is included to permit novelties to be put into the room through the port. The conveyor extends from the port, through the hardening room and vestibule, and into the freezing and packaging area. Handling time in storing ice cream is reduced by extending the conveyor 5 feet into the freezing and packaging area, so that the conveyor will be adjacent to the worktable used for bagging containers.

Dry storage room

The dry storage room is used for storing nonperishable ingredients such as cane sugar, corn sugar, and chocolate powder; empty cartons, cans, and bags; cleaning supplies; and miscellaneous small repair parts for plant equipment.

A plant manufacturing 150,000 gallons of ice cream annually receives supplies periodically, often in less than trucklot shipments. As a result supplies of some items are held in storage longer than they would be held in a plant manufacturing a considerably larger volume of ice cream a year. Nonperishable ingredients are received from one to six times a year, empty cartons, cans, and bags from one to three times a year, and cleaning supplies from three to four times a year. A dry storage room for an ice cream plant manufacturing 150,000 gallons annually should provide ample space for housing supplies to maintain a reasonable inventory and ample aisle and working space.

Based on a study of the receipt of supplies and methods of storing supplies, 118 square feet of space is suggested for storing nonperishable ingredients; 339 square feet for storing empty cartons, cans, and bags; 25 square feet for cleaning supplies and miscellaneous small repair parts; and 162 square feet of aisle and working space. The total space suggested amounts to 644 square feet.

A room 24 feet wide and 26 feet 10 inches deep is suggested for dry storage.

In the proposed layout the room adjoins the mix area to minimize hauling distances. A 6-foot aisle separates two storage areas measuring 9 feet by 26 feet 10 inches. An open doorway at one end of the room leads directly into the mix area, and swinging doors are used at the delivery entrance. All supplies should be stacked on floor storage racks, and repair parts should be stored in cabinets. Other than storage facilities, no equipment is required.

Machinery room

The machinery room houses steam generation equipment, refrigeration compressors, a sweetwater (ice water) tank, an electrical panel, and a small repair shop.

In the proposed layout, the room is located to reduce refrigeration losses by minimizing the distance from the refrigeration equipment to the freezers, plate cooler, and hardening room. It is located adjacent to the hardening room and the freezing and packaging area. A small maintenance area is located at the end of the room which opens into the freezing and packaging area. A 7-foot-wide door in the outer wall is provided for moving large equipment in or out of the plant. An aisle 7 foot 6 inches is provided for equipment maintenance and for moving equipment through the room. The room covers an area 34 feet 9 inches by 13 feet and contains 451.8 square feet of space.

Laboratory

The laboratory covers an area 10 feet long by 13 feet wide. The room is used primarily for testing incoming and outgoing products for butterfat content, acidity, bacteria count, etc. Work counters should line the room on three sides.

Lockers and toilet

The locker room contains lockers, showers, sinks, and toilets for plant employees. The room, measuring 12 feet by 13 feet, is located in a corner of the plant, to avoid proximity with food-handling areas.

A locker room should not open directly into any room that contains ingredients, products, containers, or processing equipment. An employee entrance is located at the end of the corridor adjacent to the locker room.

Offices

The production manager's office measures 11 feet by 13 feet. Most of the wall facing production areas should be glass paneled to permit the production manager to observe plant operations.

The main office, measuring 16 feet by 50 feet, is designed to accommodate the general manager's or owner's office, and the necessary sales, accounting, and clerical force. Toilets are included for the office force.

Expansion of plant

Since the space requirements of ice cream plants typically increase at rates in excess of original estimates, the proposed plant was designed to facilitate expansion. A layout was developed to show the effect on plant size of increasing production to 300,000 gallons annually (fig. 28).

Certain work areas need not be considered as creating potential space problems in an expansion program. If production requirements were to be greatly increased, it is likely that the batch mix-making equipment would be replaced by H.T.S.T. equipment. Such a change would have little effect on the space requirements. Furthermore, it is not likely that additional freezers of the same type would be purchased. Instead, one of the present freezers would probably be replaced by a high-capacity freezer. An increase in can storage requirements would be handled by ordering more frequently, or possibly by converting to a bulk receiving system.

If necessary, the main office could be expanded by extending the room in either of two directions. No need is foreseen for increasing the area of the production manager's office, the laboratory, or the locker room.

There are three rooms, however, which would require expansion as production increased. These rooms are the hardening room, the machinery room, and the dry storage room. The three rooms

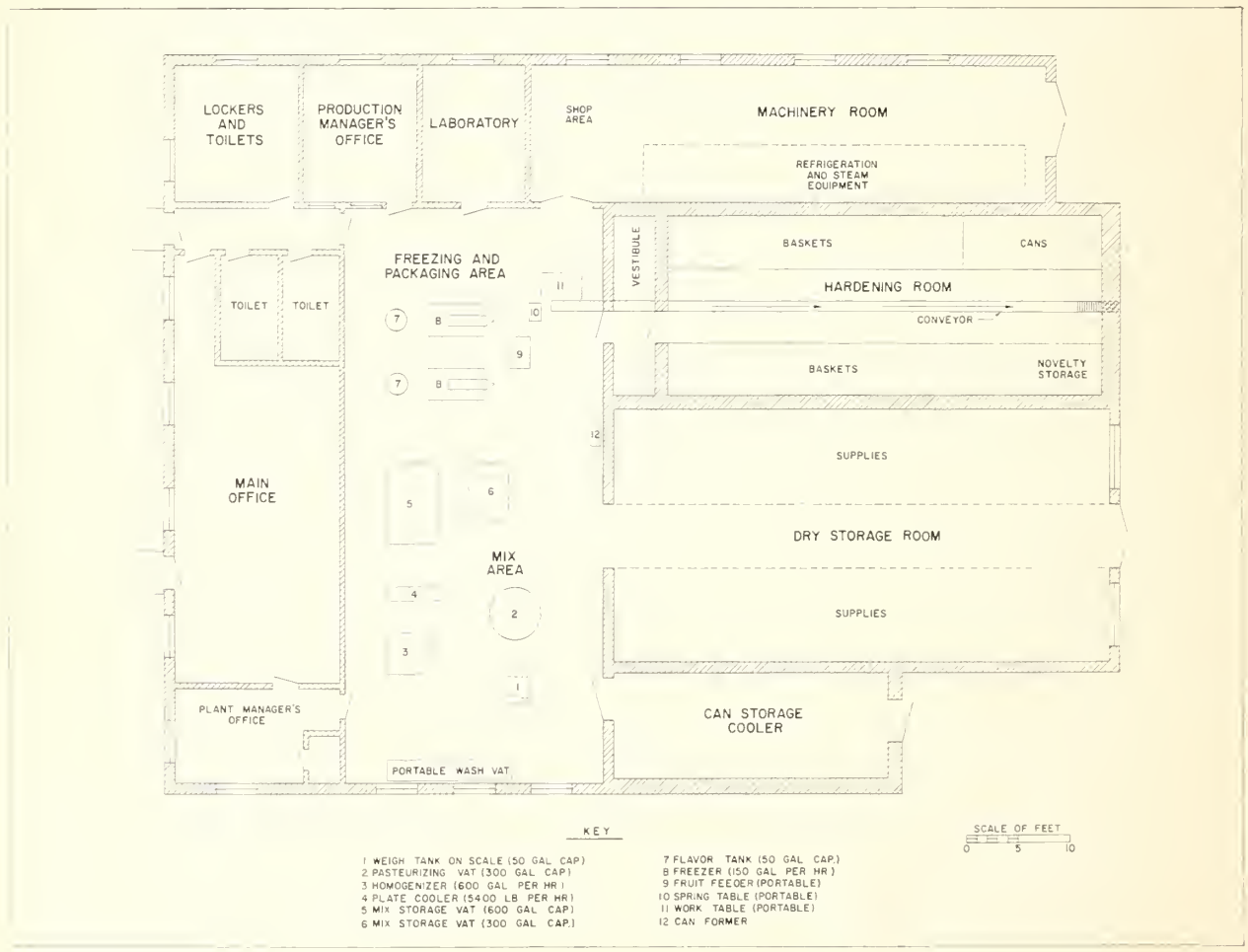

FIGURE 28.—Layout of proposed 150,000-gallon-per-year plant expanded to handle an annual volume of 300,000 gallons.

are situated adjacently along one outside wall, and could all be extended simultaneously by removing the wall. The widths of the three rooms would not be changed. In the hardening room no change would be made in the vestibule. The storage area, however, would be doubled in length to 42 feet. Therefore, the size of the entire hardening room would be increased from 26 feet by 17 feet to 47 feet by 17 feet. As a result of increased equipment requirements, the machinery room would be enlarged from 34 feet 9 inches by 13 feet to 49 feet 9 inches by 13 feet. Additional space requirements for dry supplies would necessitate enlarging the storage room from 26 feet 10 inches by 24 feet to 48 feet by 24 feet. Thus to double the volume of ice cream manufactured annually, it would be necessary to increase the total plant area to 6,132 square feet, or 22.95 percent.

AUTOMATION IN THE ICE CREAM INDUSTRY

For many years certain ice cream manufacturing operations have been performed mechanically. Only in recent years, however, have automatic controls been used in these mechanized operations. Savings resulting from the substitution of automation for conventional operating methods must be sufficiently large to offset the cost of purchasing, installing, and operating the necessary control devices. Plants manufacturing relatively large volumes of ice cream have realized such savings. However, 85 percent of the estimated 3,400 ice cream plants in the country manufacture less than 250,000 gallons annually. It is doubtful that plants in this group can economically justify the use of many of the various items of automatic equipment currently available.

Some of the automated equipment available, and areas of work in which the development of additional automated equipment should be considered, are discussed below by major operating cycles.

Receiving mix ingredients

Completely automated systems are now in use for receiving mix ingredients. Bulk-receiving tanks and panel-controlled pumps permit a worker to receive cream, condensed skim milk, liquid cane sugar, and liquid corn sugar without leaving the master control panel. Sensitive measuring devices situated beneath storage tanks weigh the tank contents and relay the information to the control panel. As the tank load reaches a predetermined level, valves are automatically actuated to divert the incoming ingredient to another tank.

Preparing mix

Programing devices at the control panel regulate assembling, mixing, processing, and storing operations. The panel operator merely sets the programer for the desired quantity of ingredients and sequence of operations. The device then actuates the entire operating cycle by controlling automatically operated pumps and valves.

Freezing ice cream

A recent innovation in freezing ice cream is a freezer that can be stopped for several minutes, and then restarted without the usual rerun period while ice cream reaches packaging consistency. The freezer can be started after several minutes downtime, and will instantly discharge ice cream as stiff as that discharged before the shutdown. The only rerun necessary will be softened ice cream in the freezer-filler pipe. Also available is an improved device for blending the output of two freezers.

Packaging ice cream

Many items of automatic equipment are available for packaging ice cream. Carton-filling machines will handle half-gallons, quarts, or pints, or one or two smaller size cartons. The machines, however, are not adaptable to various carton sizes. Cup-filling machines are more versatile; they handle cups ranging in size up to one quart. At this time there is no automatic packaging machine for gallon cartons on the market. Nor is there any device for automatically forming, filling, and closing bulk ice cream cans. Machines for wrapping individual cartons or groups of cartons are in common use. No machine was available at the time this study was made for automatically loading and sealing bags. Development of a completely automatic freezing-packaging system would eliminate much time now devoted to adjusting and synchronizing freezing and packaging machines.

Storing and loading out ice cream

The following items of equipment are now available for storing and loading out: Automatic routing systems joining the packaging area and the hardening room; automatic hardening tunnels; overhead conveyors; and automatic temperature controls. Ice cream packages can be conveyed to a hardening tunnel, hardened, and discharged. Manually loaded overhead conveyors move hardened packages to the storage site, store them, and then transfer them to the load-out port.

Cleaning manufacturing equipment

Perhaps the greatest emphasis on ice cream automation has been directed toward cleaning equipment. Piping can be cleaned in place by circu-

lating solutions. Vats and tanks can be cleaned by portable or permanently installed high-pressure spray units. Pasteurizers, plate coolers, and homogenizers can be cleaned by circulation; circulatory cleaning of homogenizers, however, is apt to result in worn and pitted valves and cylinders, necessitating expensive maintenance or replacement. A vat designed to provide high-speed circulation of cleaning solutions may be used to clean piping and machine parts from equipment that is dismantled. Programing devices, such as those employed for preparing mix, can be used for complete automatic control of circulation cleaning. The system adds cleaning agents to wash water and controls the cleaning operations for all equipment according to a preset sequence. A disadvantage of certain types of programing devices is that once the programing is started, it cannot be changed or stopped until the cycle of operations is completed. Thus, the automatic controls are still subject to human error. Positive displacement-type pumps, such as freezer mix pumps, should not be cleaned by circulation, but should be bypassed and washed manually. Packaging machines, fruit feeders, and exterior surfaces of tanks and machines must be cleaned manually.

APPENDIX

Fifteen tables have been prepared as aids in comparing equipment costs and labor requirements. Table 13 shows ownership and operating costs for each item of equipment used. Table 14 shows the fatigue and personal allowances for performing each element in receiving ingredients, preparing ice cream mix, freezing, packaging, storing, and loading out ice cream, and cleaning manufacturing equipment. Tables 15 to 27 inclusive, show the time required for performing each element of these operations, by each method of handling.

Equipment	Amount of equipment	Size or capacity	Initial cost [1]	Expected life
			Dollars	*Years*
Receiving ingredients and preparing mix:				
4-wheel handtruck [9 10 11]	1	30 x 48 in	150.00	15
4-wheel handtruck [10 11 12]	1	30 x 48 in	150.00	15
Centrifugal pump [9]	1	6,000 lb. per hr	194.00	18
Cream storage tank [9]	1	600 gal	2,145.00	20
Skim milk storage tank [9]	1	600 gal	2,145.00	20
Piping and fittings [9]	22 ft.	2-inch diam	467.28	14
Centrifugal pump [10 11]	1	6,000 lb. per hr	194.00	18
Piping and fittings [10 11]	14½ ft.	1½ in. diam	566.61	14
Weigh tank [10 11]	1	50 gal	500.00	17
Weigh tank [13 14]	1	50 gal	500.00	17
Platform scale [10 11]	1	2,000 lb	910.00	15
Platform scale [13 14]	1	2,000 lb	910.00	15
Centrifugal pump [10 11 13 14]	1	6,000 lb. per hr	194.00	18
Piping and fittings [10 13]	9½ ft.	1½-in. diam	126.49	14
Piping and fittings [11 14]	12½ ft.	1½-in. diam	151.80	14
Pasteurizing vat [11 14]	1	300 gal	4,275.00	20
Mix tank [10 13]	1	300 gal	1,850.00	20
Centrifugal pump [10 13]	1	6,000 lb. per hr	194.00	18
H.T.S.T. pasteurizer [10 13]	1	5,400 lb. per hr	12,350.00	12
Centrifugal pump [10 13 15]	1	10,000 lb. per hr	365.00	18
Homogenizer [10 11 13 14]	1	600 gal. per hr	4,160.00	17
Plate cooler [11 14]	1	5,400 lb. per hr	5,220.00	18
Storage vat [10 11 13 14]	1	600 gal	2,145.00	20
Storage vat [10 11 13 14]	1	300 gal	1,495.00	20
Piping and fittings [10 13]	27 ft.	1½-in. diam	582.13	14
Piping and fittings [11 14]	31 ft.	1½-in. diam	569.23	14
Freezing:				
Centrifugal pump [16 17]	2	6,000 lb. per hr	388.00	18
3-tube freezer [16]	1	300 gal. per hr	16,000.00	16
2 tubes				
1 tube				
3-compartment flavor tank [16]	1	375 gal	2,700.00	20
Single-tube freezer [17]	1	150 gal. per hr	8,000.00	16
Flavor tank [17]	1	50 gal	1,450.00	20
Single-tube freezer [17]	1	150 gal. per hr	8,000.00	16
Flavor tank [17]	1	50 gal	1,450.00	20
Fruit feeder [16]	1		3,250.00	15
Fruit feeder [17]	1		3,250.00	15
Piping and fittings [16]	47 ft.	1½-in. diam	1,026.11	14
Piping and fittings [17]	41½ ft.	1½-in. diam	878.13	14
Packaging, storing, and loading out:				
Single-spindle can former [20 21]	1		550.00	15
Bulk filling device [20 21]	1		150.00	12
Roller conveyor [20]	12 ft.	12 in. wide	156.40	14
Platform scale [20]	1	125 lb	579.00	15
Can stamping device [20]	1		175.00	10
Worktable [22]	1	30 x 48 in	185.00	15
Worktable [23]	1	30 x 48 in	185.00	15
Worktable [24]	1	30 x 48 in	185.00	15
Table scale [21 25]	1	40 lb	285.00	15
Filling head attachment [26]	1		75.00	14
Spring table [27]	1	12 x 18 in	125.00	15
Bagging chute [28]	1		75.00	5
Tape dispenser [25]	1		125.00	10
Wire baskets [29]	430	8 x 30 x 10½ in	1,612.50	5
Wire baskets [31]	106	8 x 30 x 10½ in	397.50	5
Half-gallon filler [33]	1	900 gal. per hr	10,670.00	15
Pint filler [34]	1	300 gal. per hr	8,020.00	15
Filling head attachment [35]	1		75.00	14
Bagging chute [36]	1		75.00	5
Cup filler and capper [37]	1	80 cups per min	6,030.00	15
Piping and fittings [38]	17 ft.	1½-in. diam	439.76	14
Piping and fittings [39]	17 ft.	1½-in. diam	511.36	14
Belt conveyor [40]		10 in. wide	789.00	10
Cleaning:				
Pipe washing vat [42]	1	2 x 12 ft	485.00	13
Pipe washing vat [43]	1	2 x 12 ft	485.00	13

See footnotes on page 40.

equipment for a plant manufacturing 150,000 gallons annually

Ownership cost				Operating cost			Total annual cost	Total annual usage [7]	Cost per hour [8]
Depreciation [2]	Interest [3]	Insurance and taxes [4]	Total	Power, fuel, and water [5]	Maintenance [6]	Total			
Dollars	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Hours*	*Dollars*
10.00	4.80	4.05	18.85	----------	3.50	3.50	22.35	31	0.7210
10.00	4.80	4.05	18.85	----------	3.50	3.50	22.35	130	.1719
10.78	6.15	5.24	22.17	0.49	3.77	4.26	26.43	71	.3723
107.25	67.57	57.92	232.74	59.21	37.54	96.75	329.49	8,760	.0376
107.25	67.57	57.92	232.74	59.21	37.54	96.75	329.49	8,760	.0376
33.38	15.00	12.62	61.00	----------	11.68	11.68	72.68	71	1.0237
10.78	6.15	5.24	22.17	.49	3.77	4.26	26.43	71	.3723
40.47	18.19	15.30	73.96	----------	14.17	14.17	88.13	71	1.2413
29.41	15.90	13.50	58.81	----------	10.29	10.29	69.10	180	.3839
29.41	15.90	13.50	58.81	----------	10.29	10.29	69.10	128	.5398
60.67	29.12	24.57	114.36	----------	21.23	23.23	135.59	180	.7533
60.67	29.12	24.57	114.36	----------	21.23	21.23	135.59	128	1.0593
10.78	6.15	5.24	22.17	.65	3.77	4.42	26.59	95	.2799
9.04	4.06	3.42	16.52	----------	3.16	3.16	19.68	95	.2072
10.84	4.87	4.10	19.81	----------	3.80	3.80	23.61	95	.2485
213.75	134.66	115.43	463.84	229.40	74.81	304.21	768.05	496	1.5485
92.50	58.28	49.95	200.73	4.83	32.38	37.21	237.94	239	.9956
10.78	6.15	5.24	22.17	.86	3.77	4.63	26.80	128	.2094
1,029.17	401.38	333.45	1,764.00	71.45	360.21	431.66	2,195.66	128	17.1536
20.28	11.57	9.86	41.71	8.96	7.10	16.06	57.77	442	.1307
244.71	132.29	112.32	489.32	51.84	85.65	137.49	626.81	128	4.8970
290.00	165.47	140.94	596.41	117.76	101.50	219.26	815.67	128	6.3724
107.25	67.57	57.92	232.74	255.45	37.54	292.99	525.73	8,760	.0600
74.75	47.09	40.37	162.21	158.46	26.16	184.62	346.83	8,760	.0396
41.58	18.69	15.72	75.99	----------	14.55	14.55	90.54	128	.7073
40.66	18.27	15.37	74.30	----------	14.23	14.23	88.53	128	.6916
21.56	12.30	10.48	44.34	.78	7.54	8.32	52.66	116	.4540
1,000.00	510.40	432.00	1,942.40	----------	350.00	----------	----------	----------	----------
----------	----------	----------	591.07	236.47	106.51	342.98	934.05	399	2.3410
----------	----------	----------	1,351.33	279.23	243.49	522.72	1,874.05	912	2.0549
135.00	85.05	72.90	292.95	28.89	47.25	76.14	369.09	1,427	.2586
500.00	255.20	216.00	971.20	385.32	175.00	560.00	1,531.52	736	[18] 2.0809
72.50	45.68	39.15	157.33	5.32	25.38	30.70	188.03	788	[18] .2386
500.00	255.20	216.00	971.20	374.33	175.00	549.33	1,520.53	707	[19] 2.1507
72.50	45.68	39.15	157.33	5.16	25.38	30.54	187.87	762	[19] .2465
216.67	104.00	87.75	408.42	6.45	75.83	82.28	490.70	764	.6423
216.67	104.00	87.75	408.42	4.19	75.83	80.02	488.44	497	.9828
73.29	32.94	27.70	133.93	----------	25.65	25.65	159.58	116	1.3757
62.72	28.19	23.71	114.62	----------	21.95	21.95	136.57	116	1.1773
36.67	17.60	14.85	69.12	.65	12.83	13.48	82.60	47	1.7574
12.50	4.88	4.05	21.43	----------	4.38	4.38	25.81	132	.1955
11.17	5.02	4.22	20.41	----------	3.91	3.91	24.32	132	.1842
38.60	18.53	15.63	72.76	----------	13.51	13.51	86.27	1	86.2700
17.50	5.78	4.73	28.01	----------	6.13	6.13	34.14	3	11.3800
12.33	5.92	5.00	23.25	----------	4.32	4.32	27.57	831	.0332
12.33	5.92	5.00	23.25	----------	4.32	4.32	27.57	785	.0351
12.33	5.92	5.00	23.25	----------	4.32	4.32	27.57	575	.0479
19.00	9.12	7.70	35.82	----------	6.65	6.65	42.47	31	1.3700
5.36	2.41	2.03	9.80	----------	1.88	1.88	11.68	871	.0134
8.33	4.00	3.38	15.71	----------	2.92	2.92	18.63	267	.0698
15.00	2.70	2.03	19.73	----------	5.25	5.25	24.98	120	.2082
12.50	4.13	3.38	20.01	----------	4.38	4.38	24.39	42	.5807
322.50	58.05	43.54	424.09	----------	112.88	112.88	536.97	100	[30] 5.3697
79.50	14.31	10.73	104.54	----------	27.83	27.83	132.37	186	[32] .7117
711.33	341.44	288.09	1,340.86	12.23	248.96	261.19	1,602.05	604	2.6524
534.67	256.64	216.54	1,007.85	1.57	187.13	188.70	1,196.55	232	5.1575
5.36	2.41	2.03	9.80	----------	1.88	1.88	11.68	232	.0503
15.00	2.70	2.03	19.73	----------	5.25	5.25	24.98	33	.7570
402.00	192.96	162.81	757.77	1.54	140.70	142.24	900.01	76	11.8422
31.41	14.12	11.87	57.40	----------	10.99	10.99	68.39	1,443	.0474
36.53	16.41	13.81	66.75	----------	12.78	12.78	79.53	1,311	.0607
78.90	26.04	21.30	126.24	11.80	27.62	39.42	165.66	1,311	[41] .1264
37.31	15.67	13.10	66.08	.86	13.06	13.92	80.00	128	.6250
37.31	15.67	13.10	66.08	.46	13.06	13.52	79.60	66	1.2061

[1] Based on f.o.b. factory costs.
[2] Computed by straight-line depreciation method.
[3] Based on average interest over life of the item. To compute, use $E=R(N+1)/2N$ where E is average interest, R is interest rate required for investment (6 percent), and N is life expectancy of the item.
[4] 2.7 percent of initial cost.
[5] 2.7 cents per kw.-hr. for power, 6.7 cents per therm for fuel, and 0.018 cent per gallon for water.
[6] 35 percent of the initial cost, over life of the item.
[7] Total number of hours each item of equipment is used in one or more operations.
[8] Computed average based on annual cost and hours of equipment usage.
[9] Items used for receiving ingredients by bulk, handtruck method.
[10] Items used for preparing mix by bulk and H.T.S.T. method.
[11] Items used for preparing mix by bulk and batch method.
[12] Items used for receiving ingredients by can, handtruck method.
[13] Items used for preparing mix by can and H.T.S.T. method.
[14] Items used for preparing mix by can and batch method.
[15] Used for preparing mix by bulk and H.T.S.T. and can and H.T.S.T. methods, and for cleaning type 1 equipment.
[16] Items used for freezing by three-tube method.
[17] Items used for freezing by single-tube method.
[18] Used when freezing for 5- and $2\frac{1}{2}$-gallon cans, and half-gallon cartons.
[19] Used when freezing for 5- and $2\frac{1}{2}$-gallon cans, gallon and pint cartons, and 5- and 3-ounce cups.
[20] Items used for packaging cans by single-spindle, conveyor method.
[21] Items used for packaging cans by single-spindle, manual method.
[22] Used for packaging 5- and $2\frac{1}{2}$-gallon cans by single-spindle, manual; gallon cartons by two-worker, manual and two-worker, chute, and basket methods; half-gallon cartons by three-worker, manual method; pint cartons by four-worker, manual; 5-ounce cups by four-worker, manual; and 3-ounce cups by five-worker, manual methods.
[23] Used for packaging gallon cartons by spring-table manual method, and for packaging half-gallon and pint, cartons and cups by filler, manual methods.
[24] Used for packaging gallon cartons by spring-table, chute, and basket method, or two-worker, chute, and basket method; for packaging half-gallon and pint cartons by filler, chute, and basket method, or manual, chute, and basket method; and for packaging cups by filler, basket method or manual, basket methods.
[25] Items used for packaging by the following methods: Gallon cartons—two-worker, manual; spring-table, manual; spring-table, chute, and basket; and two-worker, chute, and basket. Half-gallon cartons—two-worker, chute, and basket; three-worker, manual; filler, manual; and filler, chute, and basket. Pint cartons—filler, manual; filler, chute, and basket; four-worker, manual; and three-worker, chute, and basket. 5-ounce cups—four-worker, manual; four-worker, basket; filler, manual; and filler, basket. 3-ounce cups—two-worker, filler, manual; two-worker, filler, basket; five-worker, manual; and five-worker, basket.
[26] Items used for packaging by the following methods: Gallon cartons—two-worker, manual; spring-table, manual; spring-table, chute, and basket; and two-worker, chute, and basket. Half-gallon cartons—two-worker, chute, and basket, and three-worker, manual.
[27] Items used for packaging gallon cartons by spring-table, manual and spring-table, chute, and basket methods.
[28] Items used for packaging gallon cartons by spring-table, chute, and basket, and two-worker, chute, and basket methods; and half-gallon cartons by two-worker, chute, and basket, and filler, chute, and basket methods.
[29] Items used for packaging gallon cartons by spring-table, chute, and basket and two-worker, chute, and basket methods; half-gallon cartons by two-worker, chute, and basket and filler, chute, and basket methods; pint cartons by filler, chute, and basket and three-worker, chute, and basket methods; 5-ounce cups by four-worker, basket and filler, basket methods; and 3-ounce cups by two-worker, filler, basket and five-worker, basket methods; for storing cartons and cups by basket and conveyor method; and for loading out cartons and cups by basket and conveyor method.
[30] Cost allocated on basis of hourly usage for each operation: $2.1420 for packaging, $1.9862 for storing, and $1.2415 for loading out.
[31] Used for storing cartons and cups by the double-stack method.
[32] Cost allocated among containers on basis of volume stored for each container size.
[33] Used for packaging half-gallon cartons by filler, manual and filler, chute, and basket methods.
[34] Used for packaging pint cartons by filler, manual and filler, chute, and basket methods.
[35] Used for packaging pint cartons by four-worker, manual and three-worker, chute, and basket methods.
[36] Used for packaging pint cartons by filler, chute, and basket and three-worker, chute, and basket methods.
[37] Used for packaging 5-ounce cups by filler, manual and filler, chute, and basket methods, and 3-ounce cups by two-worker, filler, manual and two-worker, filler, basket methods.
[38] Used for packaging 5- and $2\frac{1}{2}$-gallon cans by single-spindle, manual method; gallon cartons by two-worker, manual and two-worker, chute, and basket methods; half-gallon cartons by two-worker, chute, and basket and three-worker, manual methods; pint cartons by four-worker, manual and three-worker, chute, and basket methods; 5-ounce cups by four-worker, manual and four-worker, basket methods; and 3-ounce cups by five-worker, manual and five-worker, basket methods.
[39] Used for packaging 5- and $2\frac{1}{2}$-gallon cans by single-spindle, conveyor method; gallon cartons by spring-table, manual and spring-table, chute, and basket methods; half-gallon and pint cartons by filler, manual and filler, chute, and basket methods; 5-ounce cups by filler, manual and filler, basket methods; and 3-ounce cups by two-worker, filler, manual and two-worker, filler, basket methods.
[40] 30-foot belt conveyor with 4-foot roller conveyor attached.
[41] Cost allocated on basis of hourly usage for each operation: $0.1207 for storing and $0.0057 for loading out.
[42] Used for cleaning equipment for bulk receiving, H.T.S.T. mix making, 3-tube freezing, and filler packaging.
[43] Used for cleaning equipment for can receiving, batch mix-making, single-tube freezing, and manual packaging.

TABLE 14.—*Fatigue and personal allowances for performing handling operations in ice cream manufacturing plants*

Item	Allowances		
	Fatigue	Personal	Total
	Percent	*Percent*	*Percent*
Receiving ingredients and preparing mix:			
Check and close tank drain valves, adjust intake valve, and start and stop pump	5	5	10
Load 100-pound sacks of cane and corn sugar onto 4-wheel handtruck	20	5	25
Transport 100-pound sacks by 4-wheel handtruck	10	5	15
Unload and stack 100-pound sacks	20	5	25
Push empty 4-wheel handtruck	5	5	10
Load 10-gallon cans of cream or skim milk onto 4-wheel handtruck	20	5	25
Transport full 10-gallon cans by 4-wheel handtruck	10	5	15
Unload and stack full 10-gallon cans	20	5	25
Start and stop pump	5	5	10
Weigh ingredients	5	5	10
Open sacks of cane or corn sugar and pour into mix tank (2 men)	15	5	20
Discard empty sacks	5	5	10
Get, mix, and add stabilizer to mix tank	5	5	10
Get, mix, and add emulsifier to mix tank	5	5	10
Open 10-gallon cans	5	5	10
Empty cans into weigh tank	20	5	25
Rinse cans	10	5	15
Transport empty 10-gallon cans by 4-wheel handtruck	10	5	15
Turn steam on or off	5	5	10
Freezing ice cream:			
Start and stop mix pump	5	5	10
Add flavor and coloring to mix	5	5	10
Set up freezer	5	5	10
Set up fruit feeder and fill hopper	5	5	10
Packaging ice cream in 5- and 2½-gallon cans:			
Perform all elements of can-forming operations	5	5	10
Switch cans beneath filler	5	5	10
Position lid on full can	5	5	10
Weigh can on conveyor	5	5	10
Pick up empty can	5	5	10
Place full 5-gallon can on table	15	5	20
Place full 2½-gallon can on table	10	5	15
Stamp flavor and date on can	5	5	10
Weigh can on table	5	5	10
Push aside can on table	5	5	10
Set up filler	10	5	15
Packaging ice cream in cartons:			
Perform all elements of forming, filling, and bagging operations	5	5	10
Set up equipment	10	5	15
Packaging ice cream in cups:			
Perform all elements of filling and bagging operations	5	5	10
Set up equipment	10	5	15
Storing and loading out 5- and 2½-gallon cans of ice cream:			
Pick up 5-gallon can or two 2½-gallon cans, transport 6 feet to cold room port, open door, place can on ledge, and return	10	5	15
Walk into hardening room	5	10	15
Transport 5-gallon can or two 2½-gallon cans in hardening room	10	10	20
Stack 5-gallon can or two 2½-gallon cans	15	10	25
Push 5-gallon can or 2½-gallon can onto belt conveyor from roller conveyor	5	5	10
Transfer 5-gallon can from conveyor to stack	15	10	25
Transfer 2½-gallon can from conveyor to stack	10	10	20
Transfer 5-gallon can from floor stack to conveyor	15	10	25
Transfer 2½-gallon can from floor stack to conveyor	10	10	20
Storing and loading out cartons and cups of ice cream:			
Transfer bag from worktable to conveyor	5	5	10
Pull 4 empty baskets to conveyor	5	10	15
Position empty basket for loading	5	10	15
Transfer bag from conveyor to basket	5	10	15
Pull 4 full baskets 6 feet	10	10	20
Stack baskets in 6-high stack	15	10	25
Unstack basket, carry 6 feet, and dump bags on conveyor	15	10	25
Place empty basket in stack	5	10	15
Transfer 2 bags from conveyor to stack	5	10	15
Transfer full basket from bagging table to conveyor	15	5	20
Transfer full basket from conveyor to floor	15	10	25
Pick up and carry 4 bags 6 feet from worktable to coldroom port, open door, place bags on ledge, and return	5	5	10
Pick up 4 bags from ledge	5	10	15
Carry 4 bags into hardening room	5	10	15
Stack bags on shelf	5	10	15
Cleaning manufacturing equipment:			
Perform all elements of cleaning operations	5	10	15

TABLE 15.—*Receiving ingredients for ice cream mix: Labor requirements per 1,000 gallons of ice cream in a plant manufacturing 150,000 gallons annually, by method and time item*

Method and time item	Frequency of occurrence	Productive time			Unproductive time	Total labor requirements
		Base time	Fatigue and personal allowance	Total		
	Number	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*
Bulk and handtruck method:						
Check and close tank drain valves, adjust intake valve, and start and stop pump	1	(1)	(1)	(1)		(1)
Load 100-pound sacks of cane and corn sugar onto 4-wheel handtruck	8	0.02	0.01	0.03		0.03
Transport sacks 16 feet to storage location	1	(1)	(1)	(1)		(1)
Unload and stack sacks	8	.02	.01	.03		.03
Return truck to receiving entrance	1	(1)	(1)	(1)		(1)
Machine-regulated wait time (waiting for tanks to fill)					0.47	.47
Total		.04	.02	.06	.47	.53
Can and handtruck method:						
Load 10-gallon cans of cream and skim milk onto 4-wheel handtruck	32	.06	.01	.07		.07
Move truck 11 feet to storage room	4	.03	(1)	.03		.03
Unload and stack cans	32	.06	.01	.07		.07
Return truck to receiving entrance	4	.02	(1)	.02		.02
Load 100-pound sacks of cane and corn sugar onto 4-wheel hand truck	8	.02	.01	.03		.03
Transport sacks 16 feet to storage location	1	(1)	(1)	(1)		(1)
Unload and stack sacks	8	.02	.01	.03		.03
Return truck to receiving entrance	1	(1)	(1)	(1)		(1)
Total		.21	.04	.25		.25

[1] Labor required is less than 0.01 man-hour per 1,000 gallons.

TABLE 16.—*Preparing ice cream mix: Labor requirements per 1,000 gallons of ice cream in a plant manufacturing 150,000 gallons of ice cream annually, by method and time item*

Method and time item	Frequency of occurrence	Productive time			Unproductive time	Total labor requirements
		Base time	Fatigue and personal allowance	Total		
Bulk and H.T.S.T. method:	*Number*	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*
Start and stop pump	6	0.02	(1)	0.02		0.02
Weigh ingredients	6	(1)	(1)	(1)		(1)
Load 100-pound sacks of cane and corn sugar onto 4-wheel handtruck	8	.02	0.01	.03		.03
Move truck (average distance 32 feet) to mix area	1	(1)	(1)	(1)		(1)
Open sacks, pour contents into mix tank, and put sacks aside	8	.09	.02	.11		.11
Return truck to dry storage room	1	(1)	(1)	(1)		(1)
Discard empty sacks	1	(1)	(1)	(1)		(1)
Add water to weigh tank	2	.08	.01	.09		.09
Weigh water	2	(1)	(1)	(1)		(1)
Get, mix, and add stabilizer to mix tank	3	.03	(1)	.03		.03
Get, mix, and add emulsifier to mix tank	3	.02	(1)	.02		.02
Start and stop pump	3	.02	(1)	.02		.02
Machine-regulated wait time:						
Pump cream and skim milk to weigh tank					0.47	.47
Drain cream and skim milk from weigh tank					.47	.47
Drain water from weigh tank					.17	.17
Pasteurize, homogenize, and store mix					.86	.86
Total		.28	.04	.32	1.97	2.29
Can and H.T.S.T. method:						
Push 4-wheel handtruck (average distance 15 feet) to can storage cooler	4	.03	(1)	.03		.03
Load 10-gallon cans of cream and skim milk on truck	32	.06	.01	.07		.07
Move truck (average distance 15 feet) to mix area	4	.03	(1)	.03		.03
Open cans	32	.05	.01	.06		.06
Empty cans into weigh tank	32	.10	.03	.13		.13
Weigh ingredients	6	(1)	(1)	(1)		(1)
Rinse cans	32	.09	.01	.10		.10
Return empty cans to cooler	4	.03	(1)	.03		.03
Return empty truck	4	.03	(1)	.03		.03
Load 100-pound sacks of cane and corn sugar on truck	8	.02	.01	.03		.03
Move truck (average distance 32 feet) to mix area	1	(1)	(1)	(1)		(1)
Open sacks, pour contents into mix tank, and put sacks aside	8	.09	.02	.11		.11
Return truck to dry storage room	1	(1)	(1)	(1)		(1)
Discard empty sacks	1	(1)	(1)	(1)		(1)
Add water to weigh tanks	2	.08	.01	.09		.09
Weigh water	2	(1)	(1)	(1)		(1)
Get, mix, and add stabilizer to mix tank	3	.03	(1)	.03		.03
Get, mix, and add emulsifier to mix tank	3	.02	(1)	.02		.02
Start and stop pump	3	.02	(1)	.02		.02
Machine-regulated wait time:						
Drain cream and skim milk from weigh tank					.47	.47
Drain water from weigh tank					.17	.17
Pasteurize, homogenize, and store mix					.86	.86
Total		.68	.10	.78	1.50	2.28

TABLE 16.—*Preparing ice cream mix: Labor requirements per 1,000 gallons of ice cream in a plant manufacturing 150,000 gallons of ice cream annually, by method and time item*—Continued

Method and time item	Frequency of occurrence	Productive time			Unproductive time	Total labor requirements
		Base time	Fatigue and personal allowance	Total		
Bulk and batch method:	*Number*	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*
Start and stop pump	6	.02	(1)	.02		.02
Weigh ingredients	6	(1)	(1)	(1)		(1)
Load 100-pound sacks of cane and corn sugar onto 4-wheel handtruck	8	.02	.01	.03		.03
Move truck (average distance 32 feet) to mix area	1	(1)	(1)	(1)		(1)
Open sacks, pour contents into pasteurizing vat, and put sacks aside	8	.09	.02	.11		.11
Return truck to dry storage room	1	(1)	(1)	(1)		(1)
Discard empty sacks	1	(1)	(1)	(1)		(1)
Add water to weigh tank	2	.08	.01	.09		.09
Weigh water	2	(1)	(1)	(1)		(1)
Get, mix, and add stabilizer to pasteurizing vat	3	.03	(1)	.03		.03
Get, mix, and add emulsifier to pasteurizing vat	3	.02	(1)	.02		.02
Turn on steam at pasteurizing vat	3	.04	.01	.05		.05
Turn off steam	3	.04	.01	.05		.05
Machine-regulated wait time:						
Pump cream and skim milk to weigh tank					.47	.47
Drain cream and skim milk from weigh tank					.47	.47
Drain water from weigh tank					.17	.17
Heat mix to 160° F					.84	.84
Hold mix in vat for 30 minutes					.84	.84
Homogenize, cool, and store mix					.86	.86
Total		.34	.06	.40	3.65	4.05
Can and batch method:						
Push 4-wheel handtruck (average distance 15 feet) to can storage cooler	4	.03	(1)	.03		.03
Load 10-gallon cans of cream and skim milk on truck	32	.06	.01	.07		.07
Move truck (average distance 15 feet) to mix area	4	.03	(1)	.03		.03
Open cans	32	.05	.01	.06		.06
Empty cans into weigh tank	32	.10	.03	.13		.13
Weigh ingredients	6	(1)	(1)	(1)		(1)
Rinse cans	32	.09	.01	.10		.10
Return empty can to cooler	4	.03	(1)	.03		.03
Return empty truck	4	.03	(1)	.03		.03
Load 100-pound sacks of cane and corn sugar on truck	8	.02	.01	.03		.03
Transport (average distance 32 feet) to mix area	1	(1)	(1)	(1)		(1)
Open sacks, pour contents into pasteurizing vat, and put sacks aside	8	.09	.02	.11		.11
Return truck to dry storage room	1	(1)	(1)	(1)		(1)
Discard empty sacks	1	(1)	(1)	(1)		(1)
Add water to weigh tank	2	.08	.01	.09		.09
Weigh water	2	(1)	(1)	(1)		(1)
Get, mix, and add stabilizer to pasteurizing vat	3	.03	(1)	.03		.03
Get, mix, and add emulsifier to pasteurizing vat	3	.02	(1)	.02		.02
Turn on steam at pasteurizing vat	3	.04	.01	.05		.05
Turn off steam	3	.04	.01	.05		.05
Machine-regulated time:						
Drain cream and skim milk from weigh tank					.47	.47
Drain water from weigh tank					.17	.17
Heat mix to 160° F					.84	.84
Hold mix in vat for 30 minutes					.84	.84
Homogenize, cool, and store mix					.86	.86
Total		.74	.12	.86	3.18	4.04

[1] Labor requirement is less than 0.01 man-hour per 1,000 gallons.

TABLE 17.—*Freezing ice cream: Labor requirements per 1,000 gallons in a plant manufacturing 150,000 gallons annually, by method, time item, and size of container*

Method and time item	5- and 2½-gallon cans				Gallon cartons				Half-gallon and pint cartons				5- and 3-ounce cups			
	Frequency of occurrence	Base time	Fatigue and personal allowance	Productive time	Frequency of occurrence	Base time	Fatigue and personal allowance	Productive time	Frequency of occurrence	Base time	Fatigue and personal allowance	Productive time	Frequency of occurrence	Base time	Fatigue and personal allowance	Productive time
	Number	*Man-hours*	*Man-hours*	*Man-hours*	*Number*	*Man-hours*	*Man-hours*	*Man-hours*	*Number*	*Man-hours*	*Man-hours*	*Man-hours*	*Number*	*Man-hours*	*Man-hours*	*Man-hours*
3-tube method:																
Start and stop mix pump	4	[1]	[1]	[1]	4	[1]	[1]	[1]	4	[1]	[1]	[1]	4	[1]	[1]	[1]
Add flavor and coloring to mix in flavor tank	4	0.34	0.04	0.38	4	0.34	0.04	0.38	4	0.17	0.02	0.19	4	0.17	0.02	0.19
Set up freezer	4	2.45	.25	2.70	4	2.45	.25	2.70	4	1.23	.12	1.35	4	1.23	.12	1.35
Set up fruit feeder and fill hopper	3	.44	.04	.48	3	.44	.04	.48	3	.44	.04	.48	--------	[2]	[2]	[2]
Total	--------	3.23	.33	3.56	--------	3.23	.33	3.56	--------	1.84	.18	2.02	--------	1.40	.14	1.54
Single-tube method:																
Start and stop mix pump	10	[1]	[1]	[1]	10	[1]	[1]	[1]	10	[1]	[1]	[1]	10	[1]	[1]	[1]
Add flavor and coloring to mix in flavor tank	10	.84	.08	.92	10	.42	.04	0.46	10	.42	.04	.46	10	.42	.04	.46
Set up freezer(s)	10	2.45	.25	2.70	10	1.23	.12	1.35	10	1.23	.12	1.35	10	1.23	.12	1.35
Set up fruit feeder and fill hopper	3	.44	.04	.48	--------	[2]	[2]	[2]	3	.44	.04	.48	--------	[2]	[2]	[2]
Total	--------	3.73	.37	4.10	--------	1.65	.16	1.81	--------	2.09	.20	2.29	--------	1.65	.16	1.81

[1] Labor required is less than 0.01 man-hour per 1,000 gallons.
[2] A fruit feeder is not utilized with these containers.

TABLE 18.—*Packaging ice cream in cans: Labor requirements per 1,000 gallons in a plant manufacturing 150,000 gallons annually, by method, time item, and size of container*

Method and time item	5-gallon cans						2½-gallon cans					
	Frequency of occurrence	Productive time			Unproductive time	Total labor requirements	Frequency of occurrence	Productive time			Unproductive time	Total labor requirements
		Base time	Fatigue and personal allowance	Total				Base time	Fatigue and personal allowance	Total		
	Number	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*	*Number*	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*
Single-spindle, conveyor method:												
Forming cans:												
Position side piece and top ring over spindle	200	0.21	0.02	0.23		0.23	400	0.39	0.04	0.43		0.43
Lower revolving crimper, crimp top ring to side piece, and raise crimper	200	.21	.02	.23		.23	400	.43	.04	.47		.47
Invert can on spindle	200	.14	.01	.15		.15	400	.19	.02	.21		.21
Position bottom on can	200	.13	.01	.14		.14	400	.25	.03	.28		.28
Lower crimper, crimp bottom to can, and raise crimper	200	.21	.02	.23		.23	400	.43	.04	.47		.47
Remove can from spindle, and place on table or conveyor	200	.11	.01	.12		.12	400	.22	.02	.24		.24
Subtotal		1.01	.09	1.10		1.10		1.91	.19	2.10		2.10
Filling cans:												
Switch cans beneath filler	200	.07	.01	.08		.08	400	.15	.01	.16		.16
Place lid on full can	200	.19	.02	.21		.21	400	.38	.04	.42		.42
Weigh can (every tenth can)	20	.01	[1]	.01		.01	40	.02	[1]	.02		.02
Set up filler	12	.27	.04	.31		.31	3	1.24	.19	1.43		1.43
Subtotal		.54	.07	.61		.61		1.79	.24	2.03		2.03
Machine-regulated wait time[2]					4.01	4.01					2.71	2.71
Total		1.55	.16	1.71	4.01	5.72		3.70	.43	4.13	2.71	6.84
Single-spindle, manual method:												
Forming cans [3]	200	1.01	.09	1.10		1.10	400	1.91	.19	2.10		2.10
Filling cans:												
Pick up empty cans	200	.09	.01	.10		.10	400	.19	.02	.21		.21
Switch cans beneath filler	200	.09	.01	.10		.10	400	.18	.02	.20		.20
Place full can on table	200	.17	.03	.20		.20	400	.23	.04	.27		.27
Place lid on can	200	.19	.02	.21		.21	400	.38	.04	.42		.42
Stamp flavor and date on can	200	.34	.03	.37		.37	400	.66	.07	.73		.73
Weigh can (every tenth can)	20	.01	[1]	.01		.01	40	.04	[1]	.04		.04
Push can aside	200	.14	.01	.15		.15	400	.27	.03	.30		.30
Set up filler	12	.27	.04	.31		.31	3	1.24	.19	1.43		1.43
Subtotal		1.30	.15	1.45		1.45		3.19	.41	3.60		3.60
Machine-regulated wait time [2]					3.17	3.17					1.14	1.14
Total		2.31	.24	2.55	3.17	5.72		5.10	.60	5.70	1.14	6.84

[1] Labor required is less than 0.01 man-hour per 1,000 gallons.
[2] Based on total wait time for filling cans, minus time required by same worker for forming cans.
[3] Time items and labor requirements are identical to those employed with the single-spindle conveyor method.

TABLE 19.—*Packaging ice cream in gallon cartons: Labor requirements per 1,000 gallons in a plant manufacturing 150,000 gallons annually, by method and time item*

Method and time item	Frequency of occurrence	Productive time			Unproductive time	Total labor requirements
		Base time	Fatigue and personal allowance	Total		
	Number	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*
Two-worker, manual method:						
Pick up, form, and stack empty carton	1,000	0.65	0.07	0.72		0.72
Fill carton by holding under filling head	1,000	7.14	(1)	7.14		7.14
Close full carton	1,000	.78	.08	.86		.86
Place full carton on table	1,000	.25	.03	.28		.28
Open bag	500	.45	.04	.49		.49
Add 2 cartons	500	.63	.06	.69		.69
Place bag on table	500	.25	.03	.28		.28
Dispense tape	500	.17	.02	.19		.19
Close and tape bag	500	.84	.09	.93		.93
Stamp flavor and date on bag	500	.36	.04	.40		.40
Weigh bag (every tenth bag)	50	.13	.01	.14		.14
Stack bag on table	500	.21	.02	.23		.23
Set up equipment	1	.71	.11	.82		.82
Machine-regulated wait time					1.93	1.93
Total		12.57	0.60	13.17	1.93	15.10
Spring-table, manual method:						
Open carton	1,000	.76	.08	.84		.84
Switch cartons on platform	1,000	.30	.03	.33		.33
Close full carton	1,000	.86	.09	.95		.95
Place carton on table	1,000	.44	.04	.48		.48
Open bag	500	.45	.04	.49		.49
Add 2 cartons	500	.63	.06	.69		.69
Place bag on table	500	.25	.03	.28		.28
Dispense tape	500	.17	.02	.19		.19
Close and tape bag	500	.84	.09	.93		.93
Stamp flavor and date on bag	500	.36	.04	.40		.40
Weigh bag (every tenth bag)	50	.13	.01	.14		.14
Stack bag on table	500	.21	.02	.23		.23
Set up equipment	1	.71	.11	.82		.82
Machine-regulated wait time					1.19	1.19
Total		6.11	.66	6.77	1.19	7.96
Spring-table, chute, and basket method:						
Open carton	1,000	.76	.08	.84		.84
Switch cartons on platform	1,000	.30	.03	.33		.33
Close full carton	1,000	.86	.09	.95		.95
Place carton on table	1,000	.44	.04	.48		.48
Open bag	500	.45	.04	.49		.49
Place bag on chute	500	.21	.02	.23		.23
Pull 2 cartons into bag	500	.30	.03	.33		.33
Place bag on table	500	.16	.02	.18		.18
Dispense tape	500	.17	.02	.19		.19
Close and tape bag	500	.84	.09	.93		.93
Weigh bag (every tenth bag)	50	.13	.01	.14		.14
Stack bag in basket	500	.27	.03	.30		.30
Position empty basket	100	.10	.01	.11		.11
Pull 4 empty baskets 4 feet to table	25	.15	.02	.17		.17
Set up equipment	1	.71	.11	.82		.82
Machine-regulated wait time					1.47	1.47
Total		5.85	.64	6.49	1.47	7.96

TABLE 19.—*Packaging ice cream in gallon cartons: Labor requirements per 1,000 gallons in a plant manufacturing 150,000 gallons annually, by method and time item*—Continued

Method and time item	Frequency of occurrence	Productive time			Unproductive time	Total labor requirements
		Base time	Fatigue and personal allowance	Total		
	Number	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*
Two-worker, chute, and basket method:						
Pick up, form, and stack empty carton	1,000	.65	.07	.72		.72
Fill carton by holding under filling head	1,000	7.14	[1]	7.14		7.14
Close full carton	1,000	.78	.08	.86		.86
Place full carton on table	1,000	.25	.03	.28		.28
Open bag	500	.45	.04	.49		.49
Place bag on chute	500	.21	.02	.23		.23
Pull 2 cartons into bag	500	.30	.03	.33		.33
Place bag on table	500	.16	.02	.18		.18
Dispense tape	500	.17	.02	.19		.19
Close and tape bag	500	.84	.09	.93		.93
Weigh bag (every tenth bag)	50	.13	.01	.14		.14
Stack bag in basket	500	.27	.03	.30		.30
Position empty basket	100	.10	.01	.11		.11
Pull 4 empty baskets 4 feet to table	25	.15	.02	.17		.17
Set up equipment	1	.71	.11	.82		.82
Machine-regulated wait time					2.21	2.21
Total		12.31	.58	12.89	2.21	15.10

[1] No fatigue or personal allowance is included since cartons are filled continuously, and the worker must stay abreast of the filling pace. To compensate for fatigue incurred while filling cartons, the two workers take turns at filling cartons.

TABLE 20.—*Packaging ice cream in half-gallon cartons: Labor requirements per 1,000 gallons in a plant manufacturing 150,000 gallons annually, by method and time item*

Method and time item	Frequency of occurrence	Productive time			Unproductive time	Total labor requirements
		Base time	Fatigue and personal allowance	Total		
	Number	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*
Two-worker, chute, and basket method:						
Pick up, form, and stack empty carton	2,000	2.00	0.20	2.20		2.20
Fill carton by holding under filling head	2,000	10.00	[1]	10.00		10.00
Close full carton	2,000	1.16	.12	1.28		1.28
Place full carton on table	2,000	.50	.05	.55		.55
Open bag	1,000	.88	.09	.97		.97
Position bag on chute	1,000	.42	.04	.46		.46
Pull 2 cartons into bag	1,000	.55	.06	.61		.61
Place bag on table	1,000	.42	.04	.46		.46
Dispense tape	1,000	.35	.04	.39		.39
Close and tape bag	1,000	1.68	.17	1.85		1.85
Weigh bag (every tenth bag)	100	.25	.03	.28		.28
Stack bag in basket	1,000	.55	.06	.61		.61
Position empty basket	167	.17	.02	.19		.19
Pull 4 empty baskets 4 feet to table	42	.06	.01	.07		.07
Set up equipment	1	.43	.06	.49		.49
Machine-regulated wait time					0.08	.08
Total		19.42	.99	20.41	.08	20.49

TABLE 20.—*Packaging ice cream in half-gallon cartons: Labor requirements per 1,000 gallons in a plant manufacturing 150,000 gallons annually, by method and time item*—Continued

Method and time item	Frequency of occurrence	Productive time			Unproductive time	Total labor requirements
		Base time	Fatigue and personal allowance	Total		
	Number	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*
Three-worker, manual method:						
Pick up, form and stack empty carton	2,000	2.00	.20	2.20		2.20
Fill carton by holding under filling head	2,000	10.00	[1]	10.00		10.00
Close full carton	2,000	1.16	.12	1.28		1.28
Place full carton on table	2,000	.50	.05	.55		.55
Open bag	1,000	.88	.09	.97		.97
Add 2 cartons	1,000	1.26	.13	1.39		1.39
Place bag on table	1,000	.52	.05	.57		.57
Dispense tape	1,000	.35	.04	.39		.39
Close and tape bag	1,000	1.68	.17	1.85		1.85
Stamp flavor and date on bag	1,000	.74	.07	.81		.81
Weigh bag (every tenth bag)	100	.25	.03	.28		.28
Stack bag on table	1,000	.42	.04	.46		.46
Set up equipment	1	.43	.06	.49		.49
Machine-regulated wait time					9.25	9.25
Total		20.19	1.05	21.24	9.25	30.49
Filler, manual method:						
Add 40 carton blanks to filling machine	50	.14	.01	.15		.15
Open bag	1,000	.88	.09	.97		.97
Add 2 cartons	1,000	1.26	.13	1.39		1.39
Place bag on table	1,000	.52	.05	.57		.57
Dispense tape	1,000	.35	.04	.39		.39
Close and tape bag	1,000	1.68	.17	1.85		1.85
Stamp flavor and date on bag	1,000	.74	.07	.81		.81
Weigh bag (every tenth bag)	100	.25	.03	.28		.28
Stack bag on table	1,000	.42	.04	.46		.46
Set up equipment	1	.83	.12	.95		.95
Machine-regulated wait time					3.13	3.13
Total		7.07	.75	7.82	3.13	10.95
Filler, chute, and basket method:						
Add 40 carton blanks to filling machine	50	.14	.01	.15		.15
Open bag	1,000	.88	.09	.97		.97
Position bag on chute	1,000	.42	.04	.46		.46
Pull 2 cartons into bag	1,000	.55	.06	.61		.61
Place bag on table	1,000	.42	.04	.46		.46
Dispense tape	1,000	.35	.04	.39		.39
Close and tape bag	1,000	1.68	.17	1.85		1.85
Weigh bag (every tenth bag)	100	.25	.03	.28		.28
Stack bag in basket	1,000	.55	.06	.61		.61
Position empty basket	167	.17	.02	.19		.19
Pull 4 empty baskets 4 feet to table	42	.06	.01	.07		.07
Set up equipment	1	.83	.12	.95		.95
Machine-regulated wait time					3.96	3.96
Total		6.30	.69	6.99	3.96	10.95

[1] No fatigue or personal allowance is included since cartons are filled continuously, and the filling worker must stay abreast of the filling pace. To compensate for fatigue incurred while filling cartons, the workers take turns at filling cartons.

TABLE 21.—*Packaging ice cream in pint cartons: Labor requirements per 1,000 gallons in a plant manufacturing 150,000 gallons annually, by method and time item*

Method and time item	Frequency of occurrence	Productive time			Unproductive time	Total labor requirements
		Base time	Fatigue and personal allowance	Total		
	Number	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*
Filler, manual method:						
Add 50 carton blanks to filling machine	160	0.41	0.04	0.45		0.45
Open bag	1,000	.88	.09	.97		.97
Place 8 cartons in bag	1,000	2.44	.24	2.68		2.68
Place bag on table	1,000	.52	.05	.57		.57
Dispense tape	1,000	.35	.04	.39		.39
Close and tape bag	1,000	1.68	.17	1.85		1.85
Stamp flavor and date on bag	1,000	.74	.07	.81		.81
Weigh bag (every tenth bag)	100	.25	.03	.28		.28
Stack bag on table	1,000	.42	.04	.46		.46
Set up equipment	2	2.85	.43	3.28		3.28
Machine-regulated wait time					1.54	1.54
Total		10.54	1.20	11.74	1.54	13.28
Filler, chute, and basket method:						
Add 50 carton blanks to filling machine	160	.41	.04	.45		.45
Open bag	1,000	.88	.09	.97		.97
Position bag on chute	1,000	.42	.04	.46		.46
Pull 8 cartons into bag	1,000	.46	.05	.51		.51
Place bag on table	1,000	.42	.04	.46		.46
Dispense tape	1,000	.35	.04	.39		.39
Close and tape bag	1,000	1.68	.17	1.85		1.85
Weigh bag (every tenth bag)	100	.25	.03	.28		.28
Stack bag in basket	1,000	.55	.06	.61		.61
Position empty basket	167	.17	.02	.19		.19
Pull 4 empty baskets 4 feet to table	42	.06	.01	.07		.07
Set up equipment	2	2.85	.43	3.28		3.28
Machine-regulated wait time					3.76	3.76
Total		8.50	1.02	9.52	3.76	13.28
Four-worker, manual method:						
Pick up, form, and stack empty carton	8,000	7.20	.72	7.92		7.92
Fill carton by holding under filling head	8,000	10.00	[1]	10.00		10.00
Close full carton and place on table	8,000	5.60	.56	6.16		6.16
Open bag	1,000	.88	.09	.97		.97
Place 8 cartons in bag	1,000	2.44	.24	2.68		2.68
Place bag on table	1,000	.52	.05	.57		.57
Dispense tape	1,000	.35	.04	.39		.39
Close and tape bag	1,000	1.68	.17	1.85		1.85
Stamp flavor and date on bag	1,000	.74	.07	.81		.81
Weigh bag (every tenth bag)	100	.25	.03	.28		.28
Stack bag on table	1,000	.42	.04	.46		.46
Set up equipment	2	1.13	.17	1.30		1.30
Machine-regulated wait time					7.91	7.91
Total		31.21	2.18	33.39	7.91	41.30

TABLE 21.—*Packaging ice cream in pint cartons: Labor requirements per 1,000 gallons in a plant manufacturing 150,000 gallons annually, by method and time item*—Continued

Method and time item	Frequency of occurrence	Productive time			Unproductive time	Total labor requirements
		Base time	Fatigue and personal allowance	Total		
	Number	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*
Three-worker, chute, and basket method:						
Pick up, form, and stack empty carton	8,000	7.20	.72	7.92		7.92
Fill carton by holding under filling head	8,000	10.00	[1]	10.00		10.00
Close full carton and place on table	8,000	5.60	.56	6.16		6.16
Open bag	1,000	.88	.09	.97		.97
Position bag on chute	1,000	.42	.04	.46		.46
Pull 8 cartons into bag	1,000	.46	.05	.51		.51
Place bag on table	1,000	.42	.04	.46		.46
Dispense tape	1,000	.35	.04	.39		.39
Close and tape bag	1,000	1.68	.17	1.85		1.85
Weigh bag (every tenth bag)	100	.25	.03	.28		.28
Stack bag in basket	1,000	.55	.06	.61		.61
Position empty basket	167	.17	.02	.19		.19
Pull 4 empty baskets 4 feet to table	42	.06	.01	.07		.07
Set up equipment	2	1.13	.17	1.30		1.30
Machine-regulated wait time					.13	.13
Total		29.17	2.00	31.17	.13	31.30

[1] No fatigue or personal allowance is included since cartons are filled continuously, and the filling worker must stay abreast of the filling pace. To compensate for fatigue incurred while filling cartons, the workers take turns at filling cartons.

TABLE 22.—*Packaging ice cream in 5-ounce cups: Labor requirements per 1,000 gallons in a plant manufacturing 150,000 gallons annually, by method and time item*

Method and time item	Frequency of occurrence	Productive time			Unproductive time	Total labor requirements
		Base time	Fatigue and personal allowance	Total		
	Number	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*
Four-worker, manual method:						
Fill cup by holding under filling spout	25,536	16.67	[1]	16.67		16.67
Place lid on cup and push aside	25,536	14.94	1.49	16.43		16.43
Seat lid with wooden block	25,536	13.23	1.32	14.55		14.55
Open bag	1,064	.95	.09	1.04		1.04
Add 2 dozen cups	1,064	6.97	.70	7.67		7.67
Add 2 dozen spoons	1,064	.76	.08	.84		.84
Place bag on table	1,064	.55	.06	.61		.61
Dispense tape	1,064	.37	.04	.41		.41
Close and tape bag	1,064	1.80	.18	1.98		1.98
Stamp flavor and date on bag	1,064	.78	.08	.86		.86
Weigh bag (every tenth bag)	107	.26	.03	.29		.29
Stack bag on table	107	.45	.04	.49		.49
Set up equipment	17	.75	.11	.86		.86
Machine-regulated wait time					4.84	4.84
Total		58.48	4.22	62.70	4.84	67.54

TABLE 22.—*Packaging ice cream in 5-ounce cups: Labor requirements per 1,000 gallons in a plant manufacturing 150,000 gallons annually, by method and time item*—Continued

Method and time item	Frequency of occurrence	Productive time			Unproductive time	Total labor requirements
		Base time	Fatigue and personal allowance	Total		
	Number	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*
Four-worker, basket method:						
Fill cup by holding under filling spout	25,536	16.67	(1)	16.67		16.67
Place lid on cup and push aside	25,536	14.94	1.49	16.43		16.43
Seat lid with wooden block	25,536	13.23	1.32	14.55		14.55
Open bag	1,064	.95	.09	1.04		1.04
Add 2 dozen cups	1,064	6.97	.70	7.67		7.67
Add 2 dozen spoons	1,064	.76	.08	.84		.84
Place bag on table	1,064	.55	.06	.61		.61
Dispense tape	1,064	.37	.04	.41		.41
Close and tape bag	1,064	1.80	.18	1.98		1.98
Weigh bag (every tenth bag)	107	.26	.03	.29		.29
Stack bag in basket	1,064	.59	.06	.65		.65
Position empty basket	177	.18	.02	.20		.20
Pull 4 empty baskets 4 feet to table	45	.06	.01	.07		.07
Set up equipment	17	.75	.11	.86		.86
Machine-regulated wait time					5.27	5.27
Total		58.08	4.19	62.27	5.27	67.54
Filler, manual method:						
Add 50 cups to hopper	511	1.73	.17	1.90		1.90
Add 500 lids to hopper	51	.38	.04	.42		.42
Open bag	1,064	.95	.09	1.04		1.04
Add 2 dozen cups	1,064	6.97	.70	7.67		7.67
Add 2 dozen spoons	1,064	.76	.08	.84		.84
Place bag on table	1,064	.55	.06	.61		.61
Dispense tape	1,064	.37	.04	.41		.41
Close and tape bag	1,064	1.80	.18	1.98		1.98
Stamp flavor and date on bag	1,064	.78	.08	.86		.86
Weigh bag (every tenth bag)	107	.26	.03	.29		.29
Stack bag on table	1,064	.45	.04	.49		.49
Set up equipment	17	2.70	.40	3.10		3.10
Machine-regulated wait time					.16	.16
Total		17.70	1.91	19.61	.16	19.77
Filler, basket method:						
Add 50 cups to hopper	511	1.73	.17	1.90		1.90
Add 500 lids to hopper	51	.38	.04	.42		.42
Open bag	1,064	.95	.09	1.04		1.04
Add 2 dozen cups	1,064	6.97	.70	7.67		7.67
Add 2 dozen spoons	1,064	.76	.08	.84		.84
Place bag on table	1,064	.55	.06	.61		.61
Dispense tape	1,064	.37	.04	.41		.41
Close and tape bag	1,064	1.80	.18	1.98		1.98
Weigh bag (every tenth bag)	107	.26	.03	.29		.29
Stack bag in basket	1,064	.59	.06	.65		.65
Position empty basket	177	.18	.02	.20		.20
Pull 4 empty baskets 4 feet to table	45	.06	.01	.07		.07
Set up equipment	17	2.70	.40	3.10		3.10
Machine-regulated wait time					.59	.59
Total		17.30	1.88	19.18	.59	19.77

[1] No fatigue or personal allowance is included since cups are filled continuously, and the filling worker must stay abreast of the filling pace. To compensate for fatigue incurred while filling cups, the four workers take turns at filling cups.

TABLE 23.—*Packaging ice cream in 3-ounce cups: Labor requirements per 1,000 gallons in a plant manufacturing 150,000 gallons annually, by method and time item*

Method and time item	Frequency of occurrence	Productive time			Unproductive time	Total labor requirements
		Base time	Fatigue and personal allowance	Total		
Two-worker, filler, manual method:	*Number*	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*
Add 50 cups to hopper	858	2.87	0.29	3.16		3.16
Add 500 lids to hopper	86	.64	.06	.70		.70
Open bag	1,786	1.57	.16	1.73		1.73
Add 2 dozen cups	1,786	12.80	1.28	14.08		14.08
Add 2 dozen spoons	1,786	1.27	.13	1.40		1.40
Place bag on table	1,786	.92	.09	1.01		1.01
Dispense tape	1,786	.63	.06	.69		.69
Close and tape bag	1,786	3.00	.30	3.30		3.30
Stamp flavor and date on bag	1,786	1.31	.13	1.44		1.44
Weigh bag (every tenth bag)	179	.45	.04	.49		.49
Stack bag on table	1,786	.75	.07	.82		.82
Set up equipment	34	1.38	.21	1.59		1.59
Machine-regulated wait time					4.52	4.52
Total		27.59	2.82	30.41	4.52	34.93
Two-worker, filler, basket method:						
Add 50 cups to hopper	858	2.87	.29	3.16		3.16
Add 500 lids to hopper	86	.64	.06	.70		.70
Open bag	1,786	1.57	.16	1.73		1.73
Add 2 dozen cups	1,786	12.80	1.28	14.08		14.08
Add 2 dozen spoons	1,786	1.27	.13	1.40		1.40
Place bag on table	1,786	.92	.09	1.01		1.01
Dispense tape	1,786	.63	.06	.69		.69
Close and tape bag	1,786	3.00	.30	3.30		3.30
Weigh bag (every tenth bag)	179	.45	.04	.49		.49
Stack bag in basket	1,786	.98	.10	1.08		1.08
Position empty basket	298	.31	.03	.34		.34
Pull 4 empty baskets 4 feet to table	50	.11	.01	.12		.12
Set up equipment	34	1.38	.21	1.59		1.59
Machine-regulated wait time					5.24	5.24
Total		26.93	2.76	29.69	5.24	34.93
Five-worker, manual method:						
Fill cup by holding under filling spout	42,864	16.67	[1]	16.67		16.67
Place lid on cup and push aside	42,864	14.95	1.49	16.44		16.44
Seat lid with wooden block	42,864	22.06	2.21	24.27		24.27
Open bag	1,786	1.57	.16	1.73		1.73
Add 2 dozen cups	1,786	12.80	1.28	14.08		14.08
Add 2 dozen spoons	1,786	1.27	.13	1.40		1.40
Place bag on table	1,786	.92	.09	1.01		1.01
Dispense tape	1,786	.63	.06	.69		.69
Close and tape bag	1,786	3.00	.30	3.30		3.30
Stamp flavor and date on bag	1,786	1.31	.13	1.44		1.44
Weigh bag (every tenth bag)	179	.45	.04	.49		.49
Stack bag on table	1,786	.75	.07	.82		.82
Set up equipment	34	.39	.06	.45		.45
Machine-regulated wait time					1.01	1.01
Total		76.77	6.02	82.79	1.01	83.80
Five-worker, basket method:						
Fill cup by holding under filling spout	42,864	16.67	[1]	16.67		16.67
Place lid on cup and push aside	42,864	14.95	1.49	16.44		16.44
Seat lid with wooden block	42,864	22.06	2.21	24.27		24.27
Open bag	1,786	1.57	.16	1.73		1.73
Add 2 dozen cups	1,786	12.80	1.28	14.08		14.08
Add 2 dozen spoons	1,786	1,27	.13	1.40		1.40
Place bag on table	1,786	.92	.09	1.01		1.01
Dispense tape	1,786	.63	.06	.69		.69
Close and tape bag	1,786	3.00	.30	3.30		3.30
Weigh bag (every tenth bag)	179	.45	.04	.49		.49
Stack bag in basket	1,786	.98	.10	1.08		1.08
Position empty basket	298	.31	.03	.34		.34
Pull 4 empty baskets 4 feet to table	50	.11	.01	.12		.12
Set up equipment	34	.39	.06	.45		.45
Machine-regulated wait time					1.73	1.73
Total		76.11	5.96	82.07	1.73	83.80

[1] No fatigue or personal allowance is included since cups are filled continuously, and the filling worker must stay abreast of the filling pace. To compensate for fatigue incurred while filling cups, the five workers take turns filling cups.

TABLE 24.—*Storing ice cream packaged in cans: Labor requirements per 1,000 gallons in a plant manufacturing 150,000 gallons annually, by method and time item*

Method and time item	Frequency of occurrence	Base time	Fatigue and personal allowance	Productive time
	Number	*Man-hours*	*Man-hours*	*Man-hours*
Manual method: [1]				
Pick up can at packaging area, transport 6 feet (average distance) to coldroom port, open port door, place can on ledge in coldroom, and return to packaging area	200	0.57	0.08	0.65
Walk 20 feet from packaging area to coldroom	33	.15	.02	.17
Transfer cans (average distance) 20 feet from ledge to stacking area	200	.31	.06	.37
Stack cans	200	.15	.04	.19
Return from stacking area to ledge (average distance 20 feet)	200	.25	.04	.29
Return to packaging area	33	.15	.02	.17
Total		1.58	.26	1.84
Conveyor method:				
5-gallon cans:				
Push cans from roller conveyor at packaging area onto belt conveyor	200	.08	.01	.09
Walk (average distance) 20 feet from packaging area to coldroom (every 12 cans)	17	.07	.01	.08
Transfer cans from conveyor to stack (average distance 2 feet)	200	.16	.04	.20
Walk from coldroom to packaging area	17	.07	.01	.08
Total		.38	.07	.45
$2\frac{1}{2}$-gallon cans:				
Push cans from roller conveyor at packaging area onto belt conveyor	400	.15	.02	.17
Walk (average distance 20 feet) from packaging area to coldroom (every 12 cans)	33	.15	.02	.17
Transfer cans from conveyor to stack (average distance 2 feet)	400	.32	.07	.39
Walk from coldroom to packaging area	33	.15	.02	.17
Total		0.77	0.13	0.90

[1] 5-gallon cans are handled singly and $2\frac{1}{2}$-gallon cans are handled 2 at a time.

TABLE 25.—*Storing cartons and cups of ice cream in bags: Labor requirements per 1,000 gallons in a plant manufacturing 150,000 gallons annually, by method, time item, and container size*

Method and time item	Gallon cartons				Half gallon or pint cartons				5-ounce cups				3-ounce cups			
	Frequency of occurrence	Base time	Fatigue and personal allowance	Productive time	Frequency of occurrence	Base time	Fatigue and personal allowance	Productive time	Frequency of occurrence	Base time	Fatigue and personal allowance	Productive time	Frequency of occurrence	Base time	Fatigue and personal allowance	Productive time
	Number	*Man-hours*	*Man-hours*	*Man-hours*	*Number*	*Man-hours*	*Man-hours*	*Man-hours*	*Number*	*Man-hours*	*Man-hours*	*Man-hours*	*Number*	*Man-hours*	*Man-hours*	*Man-hours*
Double-stack method:																
Transfer bag from worktable to conveyor	500	0.18	0.02	0.20	1,000	0.36	0.04	0.40	1,064	0.39	0.04	0.43	1,786	0.66	0.07	0.73
Walk 15 feet from packaging area to hardening room (every 36 bags)	14	.05	.01	.06	28	.10	.02	.12	29	.10	.02	.12	50	.18	.03	.21
Pull 4 empty baskets 4 feet	25	.03	(1)	.03	42	.06	.01	.07	43	.06	.01	.07	77	.10	.02	.12
Position empty basket for loading	100	.06	.01	.07	167	.13	.02	.15	167	.14	.02	.16	298	.24	.03	.27
Transfer bags from conveyor to basket	100	.23	.03	.26	167	.44	.07	.51	167	.48	.07	.55	298	.79	.12	.91
Pull 4 full baskets 6 feet	25	.05	.01	.06	42	.10	.02	.12	43	.10	.02	.12	77	.18	.03	.21
Stack basket in 6-high stack	100	.10	.02	.12	17	.18	.05	.23	167	.20	.05	.25	298	.33	.08	.41
Return 15 feet to packaging area	14	.05	.01	.06	28	.10	.02	.12	29	.10	.02	.12	50	.18	.03	.21
Unstack basket, carry 6 feet, and dump bags on conveyor	100	.17	.04	.21	17	.34	.08	.42	167	.36	.09	.45	298	.60	.15	.75
Place empty basket in stack	100	.06	.01	.07	17	.13	.02	.15	167	.14	.02	.16	298	.24	.03	.27
Move 4 empty baskets 4 feet	25	.03	(1)	.03	42	.06	.01	.07	43	.06	.01	.07	77	.10	.02	.12
Walk 7 feet to floor stack area	1	(1)	(1)	(1)	1	(1)	(1)	(1)	1	(1)	(1)	(1)	1	(1)	(1)	(1)
Transfer 2 bags to floor stack	250	.36	.05	.41	500	.70	.11	.81	532	.76	.11	.87	893	1.26	.19	1.45
Total		1.37	.21	1.58		2.70	.47	3.17		2.89	.48	3.37		4.86	.80	5.66
Basket and conveyor method:																
Transfer full basket from worktable to conveyor	100	.11	.02	.13	17	.22	.04	.26	167	.23	.05	.28	298	.40	.08	.48
Walk 20 feet from packaging area to hardening room (every 36 bags)	14	.06	.01	.07	28	.12	.02	.14	29	.13	.02	.15	50	.22	.03	.25
Transfer baskets from conveyor to floor	100	.11	.03	.14	17	.22	.06	.28	167	.24	.06	.30	298	.39	.10	.49
Pull 4 full baskets 6 feet	25	.05	.01	.06	42	.10	.02	.12	43	.10	.02	.12	77	.18	.03	.21
Stack baskets 6-high	100	.10	.02	.12	17	.18	.05	.23	167	.20	.05	.25	298	.33	.08	.41
Return to packaging area	14	.06	.01	.07	28	.12	.02	.14	29	.13	.02	.15	50	.22	.03	.25
Total		.49	.10	.59		.96	.21	1.17		1.03	.22	1.25		1.74	.35	2.09
Manual method:																
Pick up and carry 4 bags 6 feet from worktable to hardening room port, open door, place bags on ledge, and return	125	.38	.04	.42	250	.76	.08	.84	266	.81	.08	.89	446	1.35	.14	1.49
Walk 20 feet from packaging area to hardening room (every 48 bags)	10	.04	.01	.05	21	.09	.01	.10	22	.10	.01	.11	37	.17	.02	.19
Pick up 4 bags from ledge	125	.11	.01	.12	250	.20	.03	.23	266	.22	.03	.25	446	.36	.05	.41
Carry bags 20 feet to shelf	125	.22	.03	.25	250	.45	.07	.52	266	.48	.07	.55	446	.79	.12	.91
Stack bags on shelf	125	.14	.02	.16	250	.27	.04	.31	266	.29	.04	.33	446	.49	.07	.56
Return to ledge	125	.18	.03	.21	250	.37	.05	.42	266	.38	.06	.44	446	.65	.10	.75
Return 20 feet to packaging area	10	.04	.01	.05	21	.09	.01	.10	22	.10	.01	.11	37	.17	.02	.19
Total		1.11	.15	1.26		2.23	.29	2.52		2.38	.30	2.68		3.98	.52	4.50
Conveyor method:																
Transfer bag from worktable to conveyor	500	.18	.02	.20	1,000	.37	.04	.41	1,064	.39	.04	.43	1,786	.65	.07	.72
Walk 20 feet from packaging area to hardening room (every 36 bags)	14	.06	.01	.07	28	.12	.02	.14	29	.13	.02	.15	50	.22	.03	.25
Transfer 2 bags 4 feet from conveyor to stack	250	.36	.05	.41	500	.70	.11	.81	532	.75	.11	.86	893	1.26	.19	1.45
Return 20 feet to packaging area	14	.06	.01	.07	28	.12	.02	.14	29	.13	.02	.15	50	.22	.03	.25
Total		.66	.09	.75		1.31	.19	1.50		1.40	.19	1.59		2.35	.32	2.67

[1] Labor required is less than 0.01 man-hour per 1,000 gallons.

TABLE 26.—*Loading out cans of ice cream: Labor requirements per 1,000 gallons in a plant manufacturing 150,000 gallons annually, by method and time item*

Method and time item	Frequency of occurrence	Base time	Fatigue and personal allowance	Productive time
	Number	*Man-hours*	*Man-hours*	*Man-hours*
Manual method: [1]				
Transfer can 15 feet from floor stack to ledge	200	0.28	0.07	0.35
Return to stack	200	.19	.03	.22
Total		.47	.10	.57
Conveyor method:				
5-gallon cans:				
Transfer can from floor stack to conveyor (average distance 2 feet)	200	.16	.04	.20
$2\frac{1}{2}$-gallon cans:				
Transfer can from floor stack to conveyor (average distance 2 feet)	400	.31	.06	.37

[1] 5-gallon cans are handled singly and $2\frac{1}{2}$-gallon cans are handled 2 at a time.

TABLE 27.—*Loading out cartons and cups of ice cream in bags: Labor requirements per 1,000 gallons in a plant manufacturing 150,000 gallons annually, by method, time item, and container size*

Method and time item	Gallon cartons						Half-gallon or pint cartons					
	Frequency of occurrence	Productive time			Unproductive time	Total labor requirements	Frequency of occurrence	Productive time			Unproductive time	Total labor requirements
		Base time	Fatigue and personal allowance	Total				Base time	Fatigue and personal allowance	Total		
	Number	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*	*Number*	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*
Basket and conveyor method:												
Unstack basket, carry 6 feet, and empty bags onto conveyor	100	0.17	0.04	0.21		0.21	167	0.34	0.08	0.42		0.42
Place empty basket in stack	100	.07	.01	.08		.08	167	.13	.02	.15		.15
Pull 4 empty baskets 4 feet	25	.03	(1)	.03		.03	42	.06	.01	.07		.07
Job regulated wait time					0.12	.12					0.23	.23
Total		.27	.05	.32	.12	.44		.53	.11	.64	.23	.87
Manual method:												
Pick up 4 bags	125	.10	.02	.12		.12	250	.20	.03	.23		.23
Carry bags 15 feet from shelf to ledge	125	.14	.02	.16		.16	250	.27	.04	.31		.31
Stack bags on ledge	125	.14	.02	.16		.16	250	.27	.04	.31		.31
Return to shelf	125	.10	.02	.12		.12	250	.22	.03	.25		.25
Total		.48	.08	.56		.56		.96	.14	1.10		1.10
Conveyor method:												
Pick up 4 bags from stack	125	.10	.02	.12		.12	250	.20	.03	.23		.23
Carry bags 4 feet to conveyor	125	.11	.02	.13		.13	250	.23	.03	.26		.26
Place bags on conveyor	125	.14	.02	.16		.16	250	.28	.04	.32		.32
Return to stack	125	.09	.01	.10		.10	250	.17	.03	.20		.20
Total		.34	.07	.51		.51		.88	.13	1.01		1.01

See footnote at end of table.

TABLE 27.—*Loading out cartons and cups of ice cream in bags: Labor requirements per 1,000 gallon in a plant manufacturing 150,000 gallons annually, by method, time item, and container size*—Continued

Method and time item	5-ounce cups						3-ounce cups					
		Productive time						Productive time				
	Frequency of occurrence	Base time	Fatigue and personal allowance	Total	Unproductive time	Total labor requirements	Frequency of occurrence	Base time	Fatigue and personal allowance	Total	Unproductive time	Total labor requirements
	Number	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*	*Number*	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*
Basket and conveyor method:												
Unstack basket, carry 6 feet, and empty bags onto conveyor	167	0.35	0.09	0.44		0.44	298	0.60	0.15	0.75		0.75
Place empty basket in stack	167	.14	.02	.16		.16	298	.23	.04	.27		.27
Pull 4 empty baskets 4 feet	43	.07	.01	.08		.08	74	.11	.02	.13		.13
Job regulated wait time					0.25	.25					0.41	.41
Total		.56	.12	.68	.25	.93		.94	.21	1.15	.41	1.56
Manual method:												
Pick up 4 bags	266	.22	.03	.25		.25	446	.36	.05	.41		.41
Carry bags 15 feet from shelf to ledge	266	.29	.04	.33		.33	446	.49	.07	.56		.56
Stack bags on ledge	266	.29	.04	.33		.33	446	.49	.07	.56		.56
Return to shelf	266	.23	.03	.26		.26	446	.37	.06	.43		.43
Total		1.03	.14	1.17		1.17		1.71	.25	1.96		1.96
Conveyor method:												
Pick up 4 bags from stack	266	.22	.03	.25		.25	446	.36	.05	.41		.41
Carry bags 4 feet to conveyor	266	.23	.04	.27		.27	446	.40	.06	.46		.46
Place bags on conveyor	266	.29	.04	.33		.33	446	.49	.07	.56		.56
Return to stack	266	.18	.03	.21		.21	446	.30	.05	.35		.35
Total		.92	.14	1.06		1.06		1.55	.23	1.78		1.78

[1] Labor requirement is less than 0.01 man-hour per 1,000 gallons.

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